Canadian Environmental Protection Act

Strategic Options for the Management of Toxic Substances from the Base Metals Smelting Sector

Report of Stakeholder Consultations

Revision June 23, 1997

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DISCLAIMER

This report on stakeholder consultations is published by Environment Canada. It presents the results of the consultations, requested by the Minister of Environment and the Minister of Health, regarding management options for substances that have been designated as toxic under the *Canadian Environmental Protection Act* which are released, produced or used by the Base Metals Smelting Sector. The report was prepared by stakeholders involved in the consultations.

Publication of this report does not constitute approval by the Ministers of Environment and Health of all its content.

ABSTRACT

Various substances which are released, produced or used by the Base Metals Smelting Sector have been declared toxic under the *Canadian Environmental Protection Act* (*CEPA*). A multi-stakeholder Strategic Options Process (SOP) was launched to address the management of these substances. The report describes the SOP, and includes recommendations to Ministers of Environment and Health for the management of the *CEPA*-toxic substances for the Base Metals Smelting Sector.

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The Chair of the Strategic Options Process Issue Table would like to extend appreciation to the Issue Table Secretariat and all the active members, observers, corresponding members, consultants, and other stakeholders that contributed to the development and review of this report.

SUBMISSION OF REPORT

This Strategic Options Report is respectfully presented to the Ministers of Environment and Health.

Submitted on behalf of Issue Table members* by:

_____ _____

Patrick G. Finlay
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SUMMARY

S.1 Background

The Base Metals Smelting Sector (BMSS) releases substances that have been deemed toxic under the *Canadian Environmental Protection Act* (*CEPA*), either because they have been scheduled on the *CEPA* List of Toxic Substances (lead and mercury) or because they have been declared *CEPA* toxic following the Priority Substances List (PSL) 1 assessments (inorganic arsenic compounds, inorganic cadmium compounds, and oxidic, sulphidic and soluble inorganic nickel compounds). All of these substances are collectively referred to in this report as "the *CEPA* Substances".

The PSL assessments concluded that: 1) inorganic arsenic and its compounds are carcinogenic to humans; 2) inorganic cadmium compounds are probably carcinogenic to humans; and, 3) each of the groups, oxidic, sulphidic and soluble nickel compounds are carcinogenic to humans. It was also concluded that the levels of dissolved and soluble forms of inorganic arsenic, cadmium and nickel compounds in the vicinity of major anthropogenic sources and some natural sources exceeded the estimated effects threshold for sensitive environmental species. It has been shown that long-term exposure to either organic or inorganic mercury can permanently damage the brain, kidneys, and developing fetuses. Chronic exposure to lead is associated with blood and kidney problems, and in particular, neurological disorders. Studies have indicated that chronic exposure to small amounts of lead can be harmful. Mercury and lead are also associated with environmental impacts.

The Ministers of Health and Environment are responsible for the effective management of substances declared toxic under *CEPA*. In May 1996, an Issue Table (IT) for the BMSS Strategic Options Process (SOP) was convened to identify and evaluate options and provide advice to these Ministers. The purpose of Environment Canada in this exercise was to consider options to reduce releases and the environmental impacts of the *CEPA* Substances. Similarly, the goal of Health Canada in this undertaking was to minimize health risks by examining means to reduce human exposure to these substances.

The IT included representatives from federal departments, provincial governments, the BMSS (including two secondary lead smelters), and public advocacy groups. The IT, which was comprised of 28 active members, met ten times between May 1996 and February 1997 and held numerous working group meetings to produce this Strategic Options Report (SOR).

S.2 Releases of *CEPA* Substances from the Base Metals Smelting Sector

The Base Metals Smelting sector consists of metallurgical complexes located in British Columbia (1), Alberta (1), Manitoba (2), Ontario (5), Quebec (5) and New Brunswick (1).

The IT examined available data and information concerning releases of arsenic, cadmium, lead, mercury and nickel from the BMSS. Data sources included the National Pollutant Release Inventory (NPRI), the ARET program and data tabled by participants. The SOR includes release data for 1988, 1993 and 1995 and release projections for the year 2000. Data and projections for total releases to air, water and offsite transfers from the sector are summarized in Table S.1.

Table S.1[1]. Summary of Releases to Air and Water and Off-site Transfers of As, Cd, Pb, Hg, Ni from Base Metal Smelting Sector in Tonnes.

	1988	1993	1995	2000 P
Arsenic				
Air Releases	302.6	104.9	92.6	62.9
Water Releases	39.9	26.0	14.3	3.8
Total Releases	342.5	130.9	106.9	66.7
Transfers Off-site		9.2	8.9	18.2
Cadmium				
Air Releases	109.5	85.2	22.7	17.0
Water Releases	23.7	6.6	3.8	1.8
Total Releases	133.2	91.7	26.5	18.8
Transfers Off-site		0.0	0.0	30.0
Lead				
Air Releases	1639.3	1012.1	636.1	445.5
Water Releases	265.9	168.1	72.1	35.4
Total Releases	1905.2	1180.1	708.2	480.9
Transfers Off-site		181.8	236.1	600.4
Mercury				
Air Releases	26.87	10.08	4.41	3.21
Water Releases	1.28	0.56	0.08	0.17
Total Releases	28.15	10.64	4.48	3.38
Transfers Off-site		0.00	10.00	2.75
Nickel				
Air Releases	1372.0	500.4	616.1	613.0
Water Releases	44.7	27.1	18.7	20.5
Total Releases	1416.7	527.5	634.7	633.5
Transfers Off-site		23.3	16.5	8.6

Total Air Releases	3450.3	1712.6	1371.9	1141.7
Total Water Releases	375.5	228.2	109.0	61.6
Total Releases	3825.8	1940.9	1480.9	1203.3
Total Transfers Off-site		214.2	271.5	659.9

2000 P; releases are projected based on voluntary commitments by companies.

No data for Transfers Off-site in 1988 was available.

1 All release measurements and estimates are reported as total arsenic, cadmium, lead, mercury, and nickel rather than as the specific forms that were assessed as toxic under *CEPA*.

The IT also examined available information concerning natural and other anthropogenic sources. Several issues pertaining to the significance of natural and anthropogenic sources and of bioavailability were not resolved by the IT. Nevertheless, the BMSS is a significant source of releases of the *CEPA* Substances.

The potential for formation of dioxins and furans exists for smelters which have chlorinated plastics or other chlorinated substances in their feeds. Dioxins and furans were declared *CEPA* toxic following a PSL 1 assessment. Secondary materials containing chlorinated plastics constitute an important feed source for Noranda's copper smelter at Rouyn-Noranda, Quebec. Studies conducted by or in the presence of provincial officials at Rouyn-Noranda indicate that even at higher plastics feed rates than usual, combined releases to air and water from the smelter would not exceed 0.1 gram per year TEQ (Toxic Equivalent).

S.3 Technical Options to Reduce Releases of the *CEPA* Substances from the BMSS

Companies of the BMSS have committed voluntarily to reduce releases of *CEPA* Substances by about 70% from 1988 levels by 2000. Hatch Associates Ltd. was retained by Environment Canada to provide information to the IT. This included developing scenarios of technical options that could further reduce releases of *CEPA* Substances from the BMSS. On the basis of this information, the IT concluded that some technical options exist that could result in the further reduction of releases from the BMSS beyond the year 2000.

S.4 Current Policy and Regulatory Framework

The Issue Table recognizes that several agreements, policies, programs and regulatory instruments are currently in place for the management of the *CEPA* Substances. The Strategic Options Report considered the following :

- the Federal Toxic Substances Management Policy (TSMP);
- the Federal Pollution Prevention Strategy;
- the Canadian Council of Ministers of the Environment (CCME) Pollution Prevention Implementation Strategy;
- the Minerals and Metals Policy of the Government of Canada;
- the Canada-Ontario Agreement (COA);
- the Canada-Quebec St. Lawrence Vision 2000;
- the Accelerated Reduction/Elimination of Toxics (ARET) Program; and
- the current federal and provincial regulatory framework.

S.5 Summary of Recommendations

The following is a summary of the ten recommendations offered to the Ministers of Environment and Health in Section 9 of the SOR for the management of *CEPA* Substances released by the BMSS. Different perspectives expressed by members of the IT on the various recommendations are included in Section 9 of the SOR. For a fuller appreciation of the recommendations, implementation mechanisms and IT members' perspectives, readers are urged to review Section 9 of the SOR in its entirety.

S.5.1 Recommendation #1 - Release Reduction Targets and Schedules

It is recommended that total releases of the *CEPA* Substances from the BMSS should be reduced from 1988 levels by 80% by the year 2008 and by 90% beyond 2008 through the application of technically and economically feasible methods.

The Toxics Caucus of the Canadian Environmental Network (CEN) disagrees with this recommendation and, instead, recommends that the goal of the industry should be to virtually eliminate releases of *CEPA*-toxic and Schedule 1 substances as soon as possible, but no later than 2017. In the meantime, the industry should be required to adopt the Canada-Ontario Agreement and the St. Lawrence Vision 2000 commitments as interim reduction targets, including the following:

- reduce cadmium released by 90% from 1994 by 2000;
- reduce dioxin and furan releases (if released by smelters) by 90% by 2000; and
- reduce the remaining pollutants by 50% from 1994 levels by 2002, and by 90% by 2010.

According to the Toxics Caucus of the CEN, the virtual elimination goal and the interim targets should apply to each facility and each substance for all releases and transfers, and should be implemented through pollution prevention plans mandated by a *CEPA* regulation.

S.5.2 Recommendation #2 - Environmental Standards

It is recommended that the Canadian Council of Ministers of the Environment (CCME), in cooperation with the *CEPA* Federal-Provincial Advisory Committee (FPAC), continue their efforts to develop Canada-wide environmental ambient air and water quality guidelines for substances of relevance to the BMSS.

It is recommended that CCME develop appropriate environmental source performance guidelines for discharges to air and water, taking into account best available pollution prevention techniques and control technologies economically achievable for new and for existing smelters. These guidelines should be developed as soon as practicable but not later than the year 2000.

It is recommended that CCME develop protocols for the measurement and reporting of releases to promote consistent approaches to source sampling, analysis, release estimation and reporting, while retaining the flexibility to accommodate site-specific environmental needs and priorities.

It is recommended that stakeholders have appropriate opportunities to assist in the development of the CCME environmental guidelines and protocols. Existing standards and protocols implemented by federal or provincial regulations, guidelines, approvals and other mechanisms should be considered, in part to avoid duplication and to improve effectiveness and efficiency. Other initiatives that may influence the development of the CCME guidelines and protocols, including the proposed Canada-wide Accord on Environmental Harmonization and the Environmental Standards Sub-Agreement to the Accord, the government response to the AQUAMIN initiative, the work of CCME Task Forces on the Development of Ambient Air and Water Quality Guidelines and international developments, should also be considered.

The public review in 2001 (see Recommendation No.10) should be mandated to compare the Environmental Management Plan and the site-specific monitoring results with the CCME environmental source performance guidelines and provide recommendations concerning the need to implement these CCME guidelines through legally enforceable mechanisms.

The Toxics Caucus of the CEN is skeptical of the CCME involvement in the development of the standards, especially in light of their often-voiced concerns with the CCME harmonization proposals. The Toxics Caucus of the CEN and the Canadian Lung Association (CLA) representative prefer the immediate development and implementation of legally enforceable standards under a *CEPA* regulation. The CLA and the Toxics Caucus representatives cautioned that the establishment of Canada-wide environmental standards must not be construed as baseline discharge limits, below which discharge concentrations would not be considered to adversely impact on human health or the environment.

S.5.3 Recommendation # 3 - Site-Specific Environmental Management Plans

It is recommended that site-specific environmental management plans be developed and implemented by each BMSS facility in concert with governments, local communities and other affected stakeholders.

It is recommended that the effectiveness of this site-specific environmental management planning process be evaluated in 2001.

S.5.4 Recommendation #4 - Consistent Data and Reporting

It is recommended that standard reference methods for release monitoring, quality assurance/quality control programs, and independent verification of the system for monitoring and reporting of data be developed and implemented to support the CCME guidelines.

S.5.5 Recommendation #5 - Federal-Provincial Cooperation

It is recommended that governments develop a coordinated approach that avoids duplication in the implementation of environmental measures for the BMSS. For example, Environment Canada could explore with the provinces of British Columbia, Manitoba, Ontario, Quebec and New Brunswick the delivery of the *Secondary Lead Smelter Release Regulations* with a view to concluding administrative or equivalency agreements as soon as practicable and not later than 1999.

S.5.6 Recommendation #6 - Recycling

It is recommended that the federal government, within its jurisdictional responsibilities and resources, should, among other things:

- **work with provinces and territories, industry, and other stakeholders to enhance the efficiency and effectiveness of regulations and remove unnecessary impediments to metal recycling; and**
- **encourage development of products that take into account recyclability in their design.**

It is recommended that efforts should continue to identify and address barriers to recycling. Such barriers may include regulatory mechanisms or inequities in the tax system.

The IT notes the efforts currently in progress led by the National Round Table on the Environment and the Economy (NRTEE). This group is discussing in a multi-stakeholder forum how best to eliminate barriers and market concerns regarding recycling.

The Toxics Caucus of the CEN, in addition to supporting this recommendation, further recommends that the Standing Committee on Environment and Sustainable Development develop transition planning mechanisms to allow for an orderly transfer of technologies, for retraining workers and for restructuring primary smelters to secondary smelters, and should examine means to implement a major transformation to secondary materials over a period of 25 years.

S.5.7 Recommendation #7 - Dioxins and Furans

It is recommended that smelters which have chlorinated plastics or other chlorinated substances in their feeds, test for and report any emissions of dioxins and furans to the Federal-Provincial Task Force on Dioxins and Furans by December 1997, using standardized testing and analytical procedures, and that if found, releases of these substances be appropriately managed as TSMP Track 1 substances.

S.5.8 Recommendation #8 - Research and Development

It is recommended that industry, governments and other stakeholders should undertake cooperative scientific research programs to characterize smelter releases, validate predictive models, investigate environmental behaviours and effects, and identify and develop pollution prevention opportunities and technologies.

S.5.9 Recommendation #9 - SOR Public Education and Communication

It is recommended that governments, in cooperation wherever possible with industry and other stakeholders, establish ongoing public education and communication programs, such as outreach programs for communities in the vicinity of BMSS facilities, to ensure public awareness of the recommendations and commitments contained in this SOR and to support public accountability and review of the efforts made to respond to these recommendations and to accomplish these commitments.

S.5.10 Recommendation #10 - Public Review

It is recommended that a public review process should be initiated by the Ministers of Environment and Health in 2001 to assess the implementation and the effectiveness of the recommendations of this SOR. The evaluation should focus on the management of the *CEPA* Substances released by the BMSS to determine if further regulatory or non-regulatory action is needed, taking into account the federal policy on sustainable development.

BASE METALS SMELTING SECTOR STRATEGIC OPTIONS REPORT

1.0 INTRODUCTION

1.1 Background

The *Canadian Environmental Protection Act (CEPA)* requires the Minister of the Environment and the Minister of Health to prepare and publish a Priority Substances List (PSL) that identifies substances that may be harmful to the environment or constitute a danger to human health. *CEPA* then requires both Ministers to assess the substances on this list and determine whether they are toxic as defined by section 11 of the Act.

Section 11 states:

A substance is toxic if it is entering or may enter the environment in a quantity or concentration or under conditions:

(a) having or that may have an immediate or long-term harmful effect on the environment;

(b) constituting or that may constitute a danger to the environment on which human life depends; or

(c) constituting or that may constitute a danger in Canada to human life or health.

The first *CEPA* Priority Substances List, which was published in 1989, identified 44 substances for priority assessment. Assessment of these substances was completed in 1994, 25 substances were declared toxic as defined by section 11 of *CEPA*, 6 were declared non-toxic, and for 13 substances, insufficient information was available to make a determination.

Once a PSL substance has been assessed, *CEPA* requires the Ministers of Environment and Health to prepare a report of the assessment, make the report available to the public, and publish a summary of the report. The report must include a statement of whether the Ministers intend to recommend to the Governor-in-Council (Cabinet) that the substance be added to the List of Toxic Substances (s. 33 (1) and Schedule I) and that regulations be made with respect to the substance (s.34). If the substance is or has been placed on the List of Toxic Substances, then section 34(1) states that the Governor-in-Council may, on the recommendation of the Ministers, and after the *CEPA* Federal-Provincial Advisory Committee is given an opportunity to provide its advice under section 6 of the Act, make regulations for the effective control of the substance. The scope of the regulatory powers listed in section 34 (1) for substances deemed to be toxic is considerable and provides the framework for comprehensive regulation. The Ministers may also use non-regulatory or a mix of regulatory and non-regulatory strategies for the effective management of *CEPA* toxic substances.

1.2 The Base Metals Smelting Sector Strategic Options Process

In 1994, Environment Canada established a consultative, multi-stakeholder Strategic Options Process (SOP) to identify and evaluate options and provide advice to the Ministers regarding management of substances declared toxic under *CEPA*. The Base Metals Smelting Sector (BMSS) releases substances that have been declared *CEPA* toxic. The BMSS SOP was established in July 1995 by Mr. Tony Clarke, the Assistant Deputy Minister for the Environmental Protection Service, Environment Canada. In his letter of invitation, Mr. Clarke requested that an Issue Table be established for the BMSS SOP to prepare a Strategic Options Report containing recommendations to Ministers regarding: "the most cost-effective options for the sector to reduce emissions of and exposure to *CEPA* toxic substances; and the best means to implement the recommended options (regulatory, voluntary, market based instrument, etc.)".

At its first meeting in May 1996, the Issue Table (IT) agreed to focus its efforts on the following substances (hereafter collectively referred to as the *CEPA* Substances for the purposes of this Report):

- inorganic arsenic compounds;
- inorganic cadmium compounds;
- dioxins and furans;
- lead;
- mercury; and
- oxidic, sulphidic and soluble inorganic nickel compounds.

The IT recognizes that PCBs are included on *CEPA*'s "List of Toxic Substances" (Schedule 1). Some BMSS sites may be using electrical equipment containing PCBs and some sites may be storing PCBs that were contained in electrical equipment. However, the IT agrees that current federal and provincial regulatory efforts are addressing the PCB issue.

The BMSS IT held ten meetings between May 1996 and February 1997 to produce this Strategic Options Report (SOR). Stakeholders represented at the IT include the federal government (members and observers from Environment Canada, Health Canada, Natural Resources Canada and Industry Canada), the base metals smelting industry (including two secondary lead smelters), some provincial governments (nominated through the Federal-Provincial Advisory Committee established under section 6 of *CEPA*) and public advocacy groups (including one individual representing the Trail Lead Program, a community interest group; one individual representing the Canadian Lung Association; and two individuals representing the Toxics Caucus of the Canadian Environmental Network). A listing of individual participants and their affiliations is provided in Appendix 1.

During its deliberations, the IT considered information available in the public domain, information generated by the various members of the IT and information generated by consultants. Key documents used by the IT during its deliberations are referenced in Appendix 2 to this Report. A list of acronyms and a glossary of technical and commercial terms used in this SOR are included in Appendix 3.

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2.0 CONTEXT OF ISSUE TEAM DELIBERATIONS

The IT identified a number of factors that were considered important in establishing the overall context of its deliberations. Primary among these factors was the recognition that strategic options and recommendations presented to the Ministers in the SOR had to be developed in a manner that could complement broader environmental, social and economic policies. These include:

- sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, *Our Common Future*, 1987);
- pollution prevention strategies of the federal and provincial governments and the Canadian Council of Ministers of the Environment which foster sustainable development by promoting, as a top priority, the use of processes, practices, materials, products or energy that avoid or minimize the creation of pollutants and waste, at source, rather than trying to manage pollutants after they have been created; and
- the precautionary principle, adopted by the United Nations Conference on Environment and Development (UNCED), which provides that: "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." *UNCED, The Rio Declaration on Environment and Development, Principle 15, June 1992).*

The IT further recognizes that its deliberations are influenced by the current regulatory and non-regulatory policy framework used to manage toxic substances. Aspects of this policy framework are detailed in Section 8 of this SOR.

The IT also notes that a second Priority Substances List process (PSL II) was established in late 1995. PSL II substances of particular relevance to the BMSS include releases from primary and secondary copper and zinc smelters and refineries, and respirable particulate matter less than or equal to 10 microns. The IT deliberations did not address particulate matter by size.

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3.0 HEALTH AND ENVIRONMENTAL PROFILES FOR *CEPA* SUBSTANCES

Note: This Section and Appendix 4 were prepared by Environment Canada and Health Canada IT members with input from several other IT members.

The BMSS was selected for a sectoral strategic options process and report because the sector releases substances that have been deemed CEPA toxic. These substances have been deemed *CEPA* toxic either because: 1) they have been scheduled on the *CEPA* List of Toxic Substances; or 2) they have been declared toxic under paragraphs 11(a) and (c) of *CEPA* following the PSL 1 assessments.

The scheduled substances relevant to the BMSS are:

- lead; and
- mercury.

Following the PSL 1 assessments, the Ministers of Environment and Health declared their intent to recommend that the following substances released by the BMSS be added under subsection 33(1) of *CEPA* to the list of Toxic Substances in Schedule 1:

- inorganic arsenic compounds;
- inorganic cadmium compounds;
- polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) (hereafter referred to as dioxins and furans); and
- oxidic, sulphidic and soluble inorganic nickel compounds.

It should be noted that available data were inadequate to assess individual compounds within the groups of inorganic arsenic and nickel compounds. In addition, due to the lack of identified data on the speciation of metals in various environmental media, it was not possible to estimate the exposure of the general population to individual compounds.

Based on the PSL assessments, it was concluded that: 1) inorganic arsenic and its compounds are carcinogenic to humans; 2) inorganic cadmium and its compounds are probably carcinogenic to humans; and 3) each of groups, oxidic, sulphidic and soluble nickel compounds are carcinogenic to humans. It is important to note the route of exposure to these substances which is identified with the health effect. Inhalation of arsenic compounds, inorganic cadmium compounds, and oxidic, sulphidic and soluble inorganic nickel compounds, is associated with the development of cancer. Ingestion of inorganic cadmium compounds is also associated with the development of kidney disease and there is evidence that mild effects on the kidney are associated with levels of cadmium at or near those to which a portion of the Canadian general population is exposed. Ingestion of inorganic arsenic compounds is linked with the development of

cancers of various internal organs. These compounds are considered by Health Canada to be carcinogens with no threshold, that is substances for which the critical health effect is believed not to have a threshold. Therefore, it is assumed that there is some probability of harm at any level of exposure. The latter assumption is generally considered to be appropriate only for mutagenesis and genotoxic carcinogenesis (Health Canada, 1994).

With respect to the environmental impacts, the PSL assessments concluded that the levels of dissolved and soluble forms of inorganic arsenic compounds, inorganic cadmium compounds, and inorganic nickel compounds in the vicinity of major anthropogenic and some natural sources exceed the estimated effects threshold for sensitive environmental species.

Based on the PSL assessment, it was concluded that the compound 2,3,7,8-TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin), and to a lesser extent, the other dioxins (polychlorinated dibenzo-p-dioxins or PCDDs), and furans (polychlorinated dibenzofurans or PCDFs) substituted in the 2, 3, 7 and 8 positions, are extremely toxic to mammals, with a wide variation in sensitivity among species. Studies of human populations indicate that exposure to several milligrams of mixtures of chlorinated dioxins and furans can lead to a variety of effects on skin, eyes and sensory and behavioural processes. In the PSL assessment, Health Canada concluded that there is no adequate demonstration that human populations exposed to dioxins and furans have suffered excess cancer. However, based on the results of studies in animals, it was assumed that chlorinated dioxins and furans are non-genotoxic carcinogens and reproductive toxicants with a threshold, and therefore a tolerable daily intake for human exposure was derived. It was estimated that some fish-eating populations could have intakes that approach or exceed this guideline for intake.

It has been shown that long-term exposure[2] to either organic or inorganic mercury can permanently damage the brain, kidneys, and developing foetuses. Studies have indicated that chronic exposure[3] to even small amounts of lead can be harmful. Lead in the skeleton represents long-term accumulation and its half-life is several decades. Chronic exposure to lead is associated with blood and kidney problems, and in particular, neurological disorders. Both mercury and lead may enter the body through ingestion or inhalation or, depending on the compound, through dermal contact. Mercury is of particular concern because of its tendency to methylate, and because methyl mercury bioaccummulates and biomagnifies in the food web, which may contribute to increased

2 Exposure is defined by the U S EPA (1992) as "contact with a chemical or physical agent", and absorption, as "the uptake of water or dissolved chemicals by a cell or an organism". These terms are not synonymous, the latter term implying a greater degree of definition regarding contact with this substance. Absorption is determined by several factors in addition to exposure, one of which is bioavailability.

3 Chronic - Occurring over a long period of time either continuously or intermittently; used to describe ongoing exposures and effects that develop only after long exposure. Chronic exposure - Long-term, low-level exposure to a toxic chemical (EPA, 1992)

exposure. Lead has also has been demonstrated to cause adverse effects in several environmental species.

The purpose of Environment Canada in this exercise is to consider options to reduce the releases and environmental impacts of substances considered toxic under *CEPA*. Similarly, the goal of Health Canada in this undertaking is to minimize health risks by examining means to reduce human exposure to these substances, in accordance with the recommendations contained in the Priority Substances Assessment Reports and the "Guiding Principles for the Risk Management of Toxic Substances" (Health Canada, 1995). Because of the assessment of the inorganic arsenic compounds, inorganic cadmium compounds, and oxidic, sulphidic and soluble inorganic nickel compounds as substances for which the critical health effect (cancer) is believed not to have a threshold, effort should be directed toward reducing human exposure to the extent practicable. In view of the fact that mercury and lead have been shown to cause severe non-neoplastic (non-cancerous) health effects and that both have the potential to persist in the body, efforts should also be directed toward minimizing exposure to these substances.

It is recognised that over the past few years, the BMSS has introduced improvements in process technology and pollution control often resulting in substantial reductions in emissions. Therefore, on-going efforts to further reduce releases are in keeping with the aforementioned goals of Environment Canada and Health Canada.

It is recognized that while zero risk is always an ideal, it is not always an attainable ideal. Zero risk is unattainable for contaminants that, at least partly, are naturally occurring in the environment (Health Canada, 1990). It is also recognized that the incremental risks associated with exposure to low levels of a toxic substance may be small relative to other risks in society. Therefore, in consideration of these factors it may be both impractical and unnecessary to reduce exposure to zero.

Nonetheless, as stated in the "precautionary principle" (Principle 15 of the Rio Declaration on Environment and Development), where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. Health Canada's position is that where significant adverse health effects are known to be associated with exposure to a toxic substance, the lack of full scientific data should not prevent the consideration of control measures (Health Canada, 1995).

To the extent possible, information on concentrations of Priority Substances acquired in national surveys of ambient air, drinking water, soil and food in Canada, is used as the basis for the assessment of exposure (non-occupational) of the general population. Where possible and appropriate, information on concentrations of Priority Substances in specific locales is also used for the estimation of exposure of some "high-exposure subgroups" in the general population.

Appendix 4 includes a description of how Health Canada and Environment Canada assess the human health and environmental risks associated with exposure to various substances and provides a detailed overview of the methodology, conclusions and recommendations of the health and environmental assessments for the *CEPA* Substances released by the BMSS.

4.0 BASE METALS SMELTING SECTOR OVERVIEW

4.1 Introduction

Canada is a leading producer and exporter of copper, lead, nickel and zinc. As shown in Figure 4.1, metallurgical complexes are located in British Columbia (1), Alberta (1), Manitoba (2), Ontario (5), Quebec (5) and New Brunswick (1). This section provides an overview of the BMSS. Further details on the sector and individual facility profiles are included in Appendices 5 and 6.

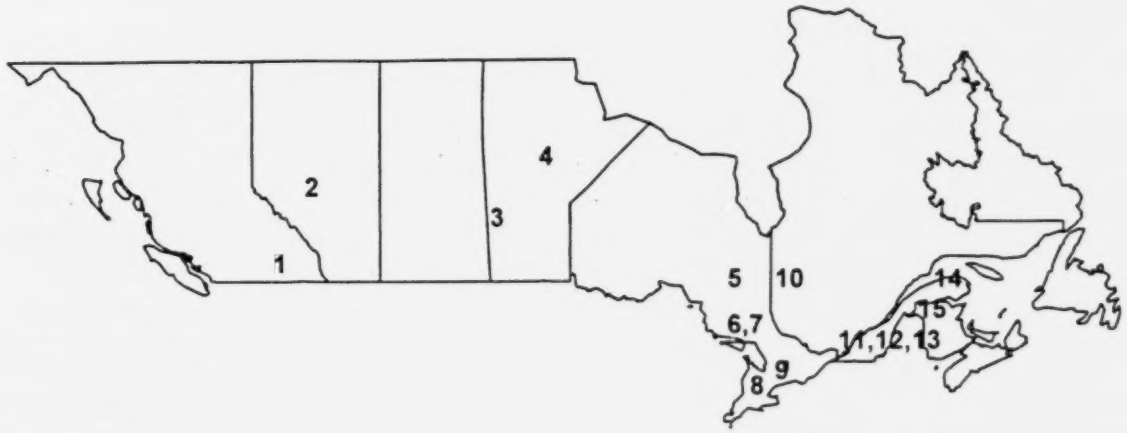
In 1995, mine production of copper, lead, nickel and zinc totaled 2.23 million tonnes, amounting to 10.8% of total world production. Canadian refined production of these metals in 1995 was 1.69 million tonnes, amounting to 6.7% of total world production. The value of metals production in 1995 amounted to $12 billion. When the value added by primary manufacturing is included, the metals sector accounted for $23 billion or 4.25% of GNP in 1995. With abundant mineral resources and a relatively small population and industrial base, Canada consumes only a small portion of its domestic metal production. As a result, Canada is the world's largest exporter of minerals and metals. Canadian refined exports of copper, lead, nickel and zinc accounted for 25% of western world exports during 1995. In 1995, mining and smelting activities associated with the BMSS in Canada provided approximately 100,000 jobs directly and 300,000 jobs indirectly.

Amongst smelter sites within Canada, there is a wide range in production and control technologies. As a result, approaches to the management of environmental concerns vary amongst facilities. The physical location of Canadian facilities also has significant implications for the operation of the facility and for the local community. Some facilities are located in remote areas where they are often the main source of employment. Sites which are more remote, especially those located far from the Great Lakes or ocean ports tend to face higher transportation costs for shipping products and by-products to market and for receiving feed materials. Thus, a facility's competitive position may be negatively impacted by an isolated location.

4.2 Competitiveness Considerations

Copper, lead, nickel and zinc are commodities for which the market is relatively mature. New applications continue to be developed but consumption in developed countries is steady, with very slow long term growth in demand and shorter term variation according to general economic conditions. Most new demand for these commodities is from rapidly growing economies in Southeast Asia and, to a lesser extent, Latin America. Demand is also affected by restrictions on major product applications or by substitution.

Figure 4.1: Canadian Base Metal Smelters and Refineries.



Province	Company	Site	Map	Facility
British Columbia	Cominco	Trail	1	Lead & Zinc Smelter/Refinery
Alberta	Sherritt	Fort Saskatchewan	2	Nickel & Cobalt Refinery
Manitoba	Hudson Bay	Flin Flon	3	Copper Smelter
				Zinc Refinery
	Inco	Thompson	4	Nickel Smelter
				Nickel Refinery
Ontario	Falconbridge*	Kidd /Timmins	5	Copper Smelter
				Copper Refinery
				Zinc Refinery
		Sudbury	6	Nickel & Copper Smelter
	Inco	Copper Cliff/Sudbury	7	Nickel & Copper Smelter
				Copper Refinery
				Nickel Refinery
		Port Colborne	8	Cobalt Refinery
	Tonolli	Mississauga	9	Secondary Lead Smelter
Quebec	Noranda	Horne/Rouyn-Noranda	10	Copper Smelter
		CEZ/Valleyfield	11	Zinc Refinery
		CCR/Montreal	12	Copper Refinery
	Nova Pb	Ville St. Catherine	13	Secondary Lead Smelter
	Noranda	Gaspé/Murdochville	14	Copper Smelter
New Brunswick	Noranda	Brunswick Smelting Belledune	15	Lead Smelter

* Noranda owns 46 % of Falconbridge

Production of refined metal depends on supplies of mine concentrates and recyclable materials and on changes in inventories. Metal prices are also influenced by changes in metal inventories. Technical innovations in exploration, mining, mineral processing and smelting technology have ensured an abundant supply of mine concentrates. Performance characteristics of secondary metals, produced from scrap rather than from concentrates, are indistinguishable from those of primary metals. As a result, metal recycling is one of the most advanced components of the recycling industry.

New technologies, heightened environmental awareness, improved waste management practices and government policies have all contributed to increased recycling rates for metals. This trend is likely to continue as manufacturers design more products for recycling. Metals are neither created nor destroyed. Improved life cycle management practices continue to increase the total amount of each metal in service and the availability of scrap as products reach the end of their life. Lead has the largest and most developed recycling component, resulting primarily from the relatively short product life and relative ease of source segregation, collection and recycling for lead-acid batteries. Copper, nickel and zinc are also recycled.

The competitive position of each smelter or refinery varies according to the cost of smelter feed materials, metal recoveries, concentrate treatment charges and terms, productivity and labour costs, energy costs, financing and other costs. A detailed examination of the competitive position of each facility could not be undertaken by the Issue Table, although members acknowledge that competitiveness considerations may influence the economic viability of technical options.

New facilities will use state of the art pollution prevention techniques and control technologies to minimize releases from these facilities. The recommendations in this SOR, including the recommended *CEPA* Substance release reductions, should not act as a disincentive for the development of new facilities in Canada.

The need for continual improvement and attention to costs at each site is illustrated by long term price trends, which reflect a dynamic balance between supply and demand and continual competitive pressure on prices. Figure A5.1 in Appendix 5 shows average annual prices for copper, lead, nickel and zinc over the period 1960 to 1995, expressed in terms of constant 1995 dollars based on the United States Consumer Price Index. Prices for copper, lead and nickel firmed somewhat in 1994 and 1995, while the price of zinc remained stagnant. Current prices for all four metals are below 1995 levels, and are at or near historic lows over the period when expressed in real terms. Competitive pressure continues to provide a growing number of consumers world wide with lower cost products, but also requires every mine and smelter operator to reduce costs and to carefully scrutinize the need for any new or increased costs.

Successful operators that intend to remain in business over the long term must be able to conserve cash when prices are low and position themselves to maximize cash inflows when prices peak. This requires successful operators to achieve and maintain a competitive cost structure. As a result, smelter operators prefer strategic investments in the development and implementation of front-end process technologies that simultaneously reduce emissions and worker exposure, improve process efficiency, and reduce energy consumption, waste production and operating costs rather than investments in end-of-pipe pollution control technologies that consume scarce capital resources and increase operating costs.

5.0 RELEASE DATA ON THE *CEPA* SUBSTANCES

5.1 Releases of Metals From The BMSS

The IT examined available data and information concerning releases of arsenic, cadmium, lead, mercury, and nickel from the BMSS. Data sources included the National Pollutant Release Inventory (NPRI), the Accelerated Reduction/Elimination of Toxics (ARET) program and data tabled by participants. Most of the available data are based on release measurements or estimates by companies. In certain cases release measurements are required by regulation or as a condition of a site-specific permit, license or approval.

Sampling and analytical procedures or data quality requirements in these cases are typically specified by a government department or agency. As a result, data generation techniques vary among facilities and direct comparisons should be made with caution. Quality assurance and quality control procedures should be designed and used to ensure that release measurements are representative of release rates under normal operating conditions over the sampling period within acceptable limits of accuracy and precision. Compliance measurements are sometimes witnessed by government inspectors to validate release measurements by verifying that the authorized sampling and analytical procedures are correctly applied.

All release measurements and estimates for release of arsenic, cadmium, lead, mercury and nickel compounds are reported as elements rather than for the specific forms that were assessed as toxic under *CEPA*. Consequently, data presented in this SOR overestimate releases of the *CEPA* Substances. Participants recognize that the use of total metal analyses introduces a degree of conservatism in the estimation of exposures to the *CEPA* Substances. For the purposes of this Report, data has been rounded off to one decimal place, except for data pertaining to mercury which has been rounded off to two decimal places.

Table 5.1 and Figure 5.1 give an overview of the total releases to air and water from the fifteen metallurgical complexes in the BMSS for the years 1988, 1993, 1995, and projections for the year 2000 for arsenic, cadmium, lead, mercury and nickel. There is a great variation in the size of the operations and the amounts of the various metals compounds that are released to the environment. Tables 5.2 to 5.6 and Figures 5.2 to 5.6 show details of the releases to air and water for each of the five elements (As, Cd, Pb, Hg, Ni) from the fifteen individual smelters and refineries in the sector. The location and type of facility are shown in Figure 4.1 in Section 4.

Tables 5.1 to 5.6 also include offsite transfers of waste. A transfer is a shipment of a listed substance in waste to an offsite location. Waste is defined as material that is sent for final disposal or for treatment prior to final disposal. (See NPRI, Summary Report 1994).

The Microsoft Excel computer program was used to manage the data in this report. The data from the individual smelters and refineries were first entered in individual tables which are shown in Appendix 6. If no data was provided for a particular metal parameter in a given year, a blank space appears in the table. If 0.0 (or 0.00 for Hg) appears in a cell in any of the tables in Appendix 6, this indicates that the reported value was sufficiently small that it appeared as zero when the figure was rounded off.

Summary Tables 5.1 to 5.6 in this section have been generated from the individual tables in Appendix 6. If a cell in Appendix 6 is blank (because there was no data), the corresponding cell in the summary table, by default, will report it as 0.0 (or 0.00 for Hg).

Thus, if readers wish to ascertain whether a zero value in a summary table results from no data being provided, or a measured value that has been rounded off to zero, they must refer to the appropriate individual table in Appendix 6.

Most data for the years 1993 and 1995 and projections for 2000 were obtained from NPRI and ARET and were verified through responses to a June 1996 questionnaire which was sent out by Hatch Associates Ltd. working under contract to Environment Canada. Data for two secondary lead smelters was obtained from a questionnaire sent by Environment Canada to the two secondary lead smelters. The questionnaires requested the smelters and refineries to provide the data on a similar basis as required by the NPRI.

The IT later decided that 1988 data should also be added to the data base. As 1993 was the first year for the NPRI data base, there was no 1988 NPRI data base from which to extract data. The 1988 data is drawn from two primary sources:

- data generated by thirteen primary smelters and refineries which was submitted to Environment Canada under a request under section 18 of *CEPA*[4]; and
- data generated by the twelve plants (members of the Mining Association of Canada) which was submitted to Environment Canada as part of the ARET Program.

In most cases the data are the same, but there are some differences depending on the instructions for collection of the data. In early December, 1996 Environment Canada provided draft tables and figures to the IT and requested the companies to review the data and provide any corrections, with appropriate explanations. The tables and figures have been modified accordingly. Explanatory notes appear at the bottom of some tables where required.

The data gathered for 1988 did not include information on offsite transfers, and as a result no data is reported for 1988 on offsite transfers.

[4]As no data were available for 1988 for the two secondary lead smelters, those companies provided data for 1987 or 1989

An appreciation of the relative contribution of the BMSS to releases suggests consideration of numerous smaller sources that make an important contribution to total anthropogenic releases and exposures. Human activities, including construction, agriculture and fuel combustion release metals to the environment. Emissions that result from fuel combustion at major industrial facilities such as thermal power generating stations may be reported to the NPRI. Some releases are more difficult to estimate, but can be significant. For example, the PSL Nickel Assessment report completed by Environment Canada and Health Canada in 1994 estimated the contribution of the BMSS to anthropogenic sources to be 67%, based on 1988 releases of 1417 tonnes from the BMSS and 1975 releases of 689 tonnes from petroleum combustion.

Current thresholds for annual NPRI reporting are based on manufacturing, processing, or otherwise using 10 tonnes or more of one of the 176 listed substances at a concentration of 1% or greater. However, if the substance is generated and released as a by-product (incidental production and separated from the process), there is no *de minimis* concentration level. For example, metals from coal-fired power plants are released as by-products in high volumes but low concentrations, and must be reported to the NPRI.

Reporting to the NPRI is based on 'manufacture' rather than releases. The NPRI thresholds may cause the exclusion of some industrial, commercial and municipal sources from reporting because the facilities do not meet the 10-tonne or 1% criteria. These facilities, if aggregated by sector, may also contribute certain quantities of metals.

While the IT recognizes that NPRI reporting criteria result in omission or underestimation of releases of *CEPA* toxic substances from some facilities outside the BMSS, it notes the most recent NPRI publication which presents reported releases for the year 1994: the BMSS contributed 97% of reported releases of arsenic and its compounds, 99% of reported releases of cadmium and its compounds, 80% of reported releases of lead and its compounds, 10% of reported releases of mercury and 90% of reported releases of nickel and its compounds. The NPRI therefore overestimates the relative contribution of the BMSS, but the sector is a significant source of releases of arsenic, cadmium, lead, mercury and nickel.

Releases of nickel from the BMSS have decreased from 1,417 tonnes in 1988 to 635 tonnes in 1995 (see Table 5.6). Fuel consumption would be expected to have increased, while nickel concentrations in fuel and in air may or may not have changed. Assuming that releases from petroleum combustion remain at 1975 levels (689 tonnes), and including other releases of 60 tonnes as reported emissions to the 1994 NPRI, total 1994 releases of nickel would be approximately 1319 tonnes and the relative contribution from the BMSS would be approximately 43%. Releases from the BMSS would likely influence concentrations of nickel in ambient air primarily in the vicinity of Thompson, Manitoba and Sudbury, Ontario while concentrations of nickel in ambient air elsewhere in Canada would likely be influenced more by fuel combustion and natural sources.

Table 5.1[5]. Summary of Releases to Air and Water and Off-site Transfers of As, Cd, Pb, Hg, Ni from Base Metal Smelting Sector in Tonnes.

	1988	1993	1995	2000 P
Arsenic				
Air Releases	302.6	104.9	92.6	62.9
Water Releases	39.9	26.0	14.3	3.8
Total Releases	342.5	130.9	106.9	66.7
Transfers Off-site		9.2	8.9	18.2
Cadmium				
Air Releases	109.5	85.2	22.7	17.0
Water Releases	23.7	6.6	3.8	1.8
Total Releases	133.2	91.7	26.5	18.8
Transfers Off-site		0.0	0.0	30.0
Lead				
Air Releases	1639.3	1012.1	636.1	445.5
Water Releases	265.9	168.1	72.1	35.4
Total Releases	1905.2	1180.1	708.2	480.9
Transfers Off-site		181.8	236.1	600.4
Mercury				
Air Releases	26.87	10.08	4.41	3.21
Water Releases	1.28	0.56	0.08	0.17
Total Releases	28.15	10.64	4.48	3.38
Transfers Off-site		0.00	10.00	2.75
Nickel				
Air Releases	1372.0	500.4	616.1	613.0
Water Releases	44.7	27.1	18.7	20.5
Total Releases	1416.7	527.5	634.7	633.5
Transfers Off-site		23.3	16.5	8.6

Total Air Releases	3450.3	1712.6	1371.9	1141.7
Total Water Releases	375.5	228.2	109.0	61.6
Total Releases	3825.8	1940.9	1480.9	1203.3
Total Transfers Off-site		214.2	271.5	659.9

2000 P. releases are projected based on voluntary commitments by companies.

5 All release measurements and estimates are reported as total arsenic, cadmium, lead, mercury, and nickel rather than for the specific forms that were assessed as toxic under *CEPA*.

Figure 5.1 Summary of Releases of Metals (As, Cd, Pb, Hg, Ni) from Base Metal Smelting Sector to Air and Water (1988, 1993, 1995 and Projected 2000)

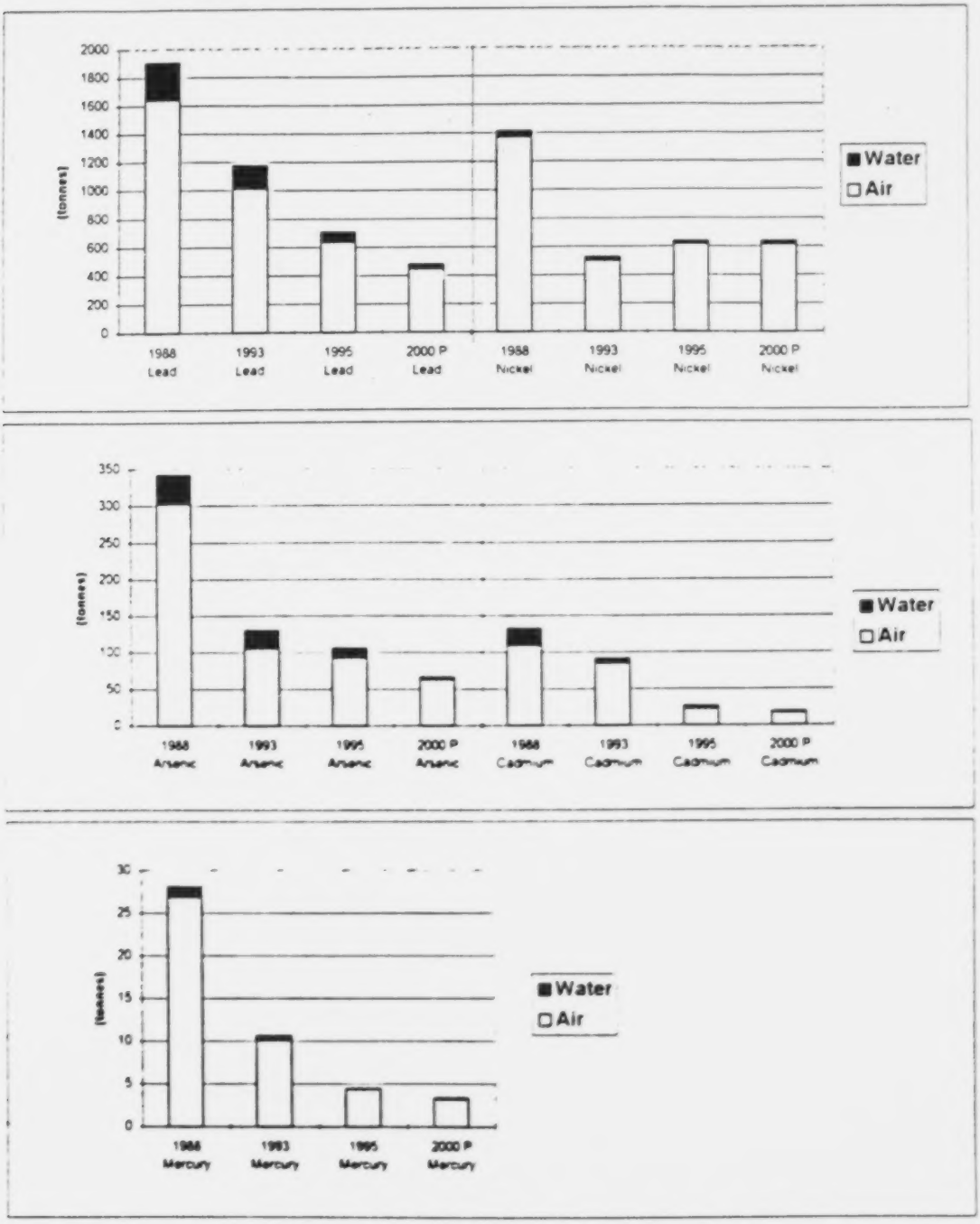


Table 5.2
Arsenic
Summary of Arsenic Releases to Air and Water and Off-site Transfers from Base Metal Smelting Sector (tonnes).

Year	1988				1993				1995				2000 Projections			
Facility	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers
Cominco	16.3	28.1	44.4	NA	7.0	21.0	28.0	0.0	14.9	11.6	26.5	0.0	6.0	1.5	7.5	0.0
Sherritt	0.0	0.1	0.1	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hudson Bay	40.6	0.0	40.6	NA	27.4	0.0	27.4	0.0	4.5	0.0	4.5	0.0	4.1	0.0	4.1	0.0
Inco Thompson	20.0	0.7	20.7	NA	6.2	1.0	7.2	0.0	4.5	1.0	5.5	0.0	5.0	1.0	6.0	0.0
Falconbridge Kidd	5.8	0.8	6.6	NA	5.2	0.8	6.0	0.0	5.6	0.0	5.6	0.0	2.0	0.0	2.0	0.0
Falconbridge Sudbury	11.7	0.0	11.7	NA	0.2	0.0	0.2	0.0	1.0	0.0	1.1	0.0	1.3	0.0	1.3	0.0
Inco Copper Cliff	35.0	0.0	35.0	NA	10.6	0.1	10.7	0.0	9.4	0.1	9.5	0.0	9.4	0.1	9.5	0.0
Inco Port Colborne	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tonolli	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Noranda Horne	113.0	0.0	113.0	NA	23.0	2.4	25.4	0.0	34.5	0.6	35.1	0.0	25.0	0.7	25.7	0.0
Noranda CEZ	0.9	0.0	0.9	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Noranda C C R.	0.3	9.3	9.6	NA	0.5	0.1	0.6	9.2	0.1	0.1	0.2	8.9	0.1	0.1	0.2	6.2
Nova Pb	0.1	0.0	0.1	NA	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Noranda Gaspe	54.2	0.2	54.4	NA	19.2	0.2	19.4	0.0	16.0	0.3	16.3	0.0	8.0	0.2	8.2	0.0
Noranda Brunswick	4.7	0.8	5.5	NA	5.5	0.3	5.8	0.0	2.0	0.6	2.6	0.0	2.0	0.2	2.2	12.0
Total	302.6	39.9	342.5	NA	104.9	26.0	130.9	9.2	92.6	14.3	106.9	8.9	62.9	3.8	66.7	18.2

NA: not available
Totals may not add up due to rounding of facility data

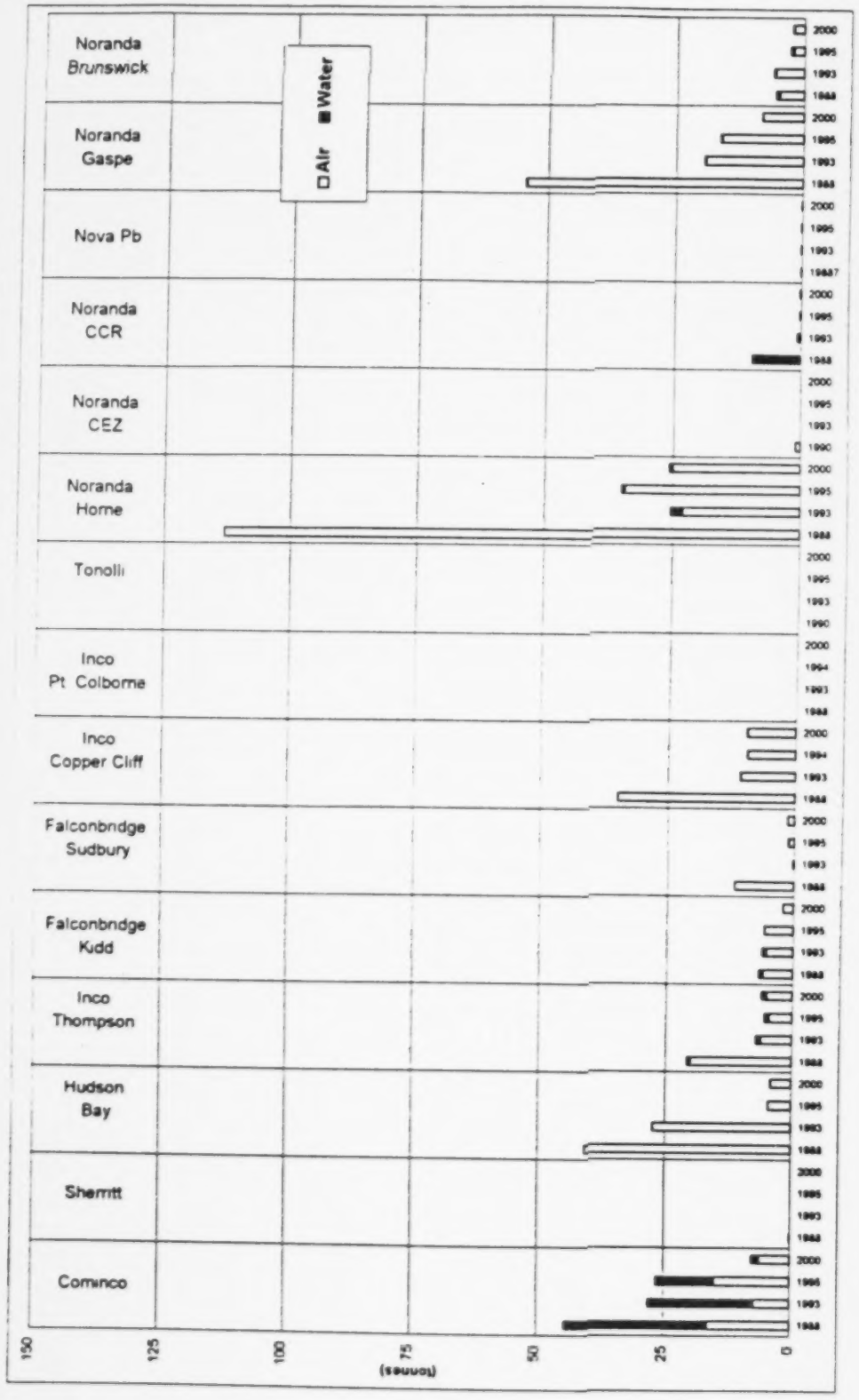


Figure 5.2 Summary of Arsenic Releases to Air and Water from Base Metal Smelting Sector.

Table 5.3
Cadmium
Summary of Cadmium Releases to Air and Water and Off-site Transfers from Base Metal Smelting Sector (tonnes).

Year	1988				1993				1995				2000 Projections			
Facility	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers
Cominco	3.9	21.0	24.9	NA	3.0	5.6	8.6	0.0	4.9	2.3	7.2	0.0	0.5	1.1	1.6	0.0
Sherritt	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hudson Bay	57.6	0.0	57.6	NA	66.8	0.0	66.8	0.0	6.0	0.0	6.0	0.0	5.8	0.0	5.8	0.0
Inco Thompson	0.1	0.0	0.1	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Falconbridge Kidd	1.6	0.2	1.8	NA	0.4	0.2	0.6	0.0	0.6	0.1	0.7	0.0	0.3	0.1	0.4	0.0
Falconbridge Sudbury	1.9	0.0	1.9	NA	5.6	0.0	5.6	0.0	4.5	0.0	4.5	0.0	1.6	0.0	1.6	0.0
Inco Copper Cliff	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inco Port Colborne	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tonolli	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Noranda Horne	39.0	0.4	39.4	NA	5.4	0.1	5.5	0.0	3.9	0.1	4.0	0.0	6.0	0.1	6.1	0.0
Noranda CEZ	0.4	0.4	0.8	NA	0.3	0.0	0.4	0.0	0.9	0.0	0.9	0.0	0.1	0.0	0.1	0.0
Noranda C C R	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nova Pb	0.0	0.0	0.0	NA	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Noranda Gaspe	1.6	0.3	1.9	NA	0.3	0.2	0.5	0.0	0.2	0.3	0.5	0.0	0.2	0.2	0.4	0.0
Noranda Brunswick	3.4	1.5	4.9	NA	3.2	0.4	3.6	0.0	1.7	1.0	2.7	0.0	2.5	0.2	2.7	30.0
Total	109.5	23.7	133.2	NA	85.2	6.6	91.7	0.0	22.7	3.8	26.5	0.0	17.0	1.8	18.8	30.0

NA: not available
Totals may not add up due to rounding of facility data

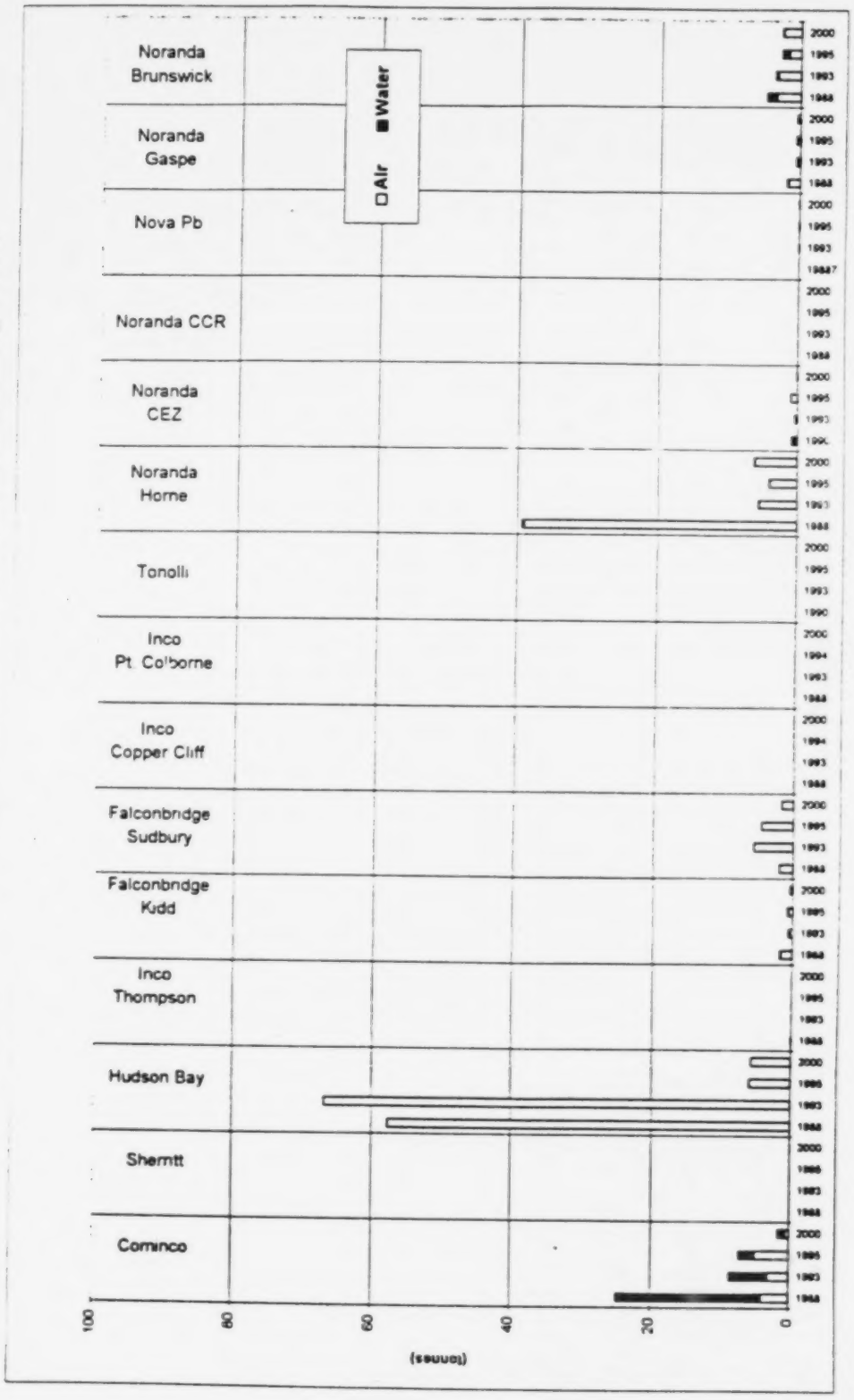


Figure 5.3 Summary of Cadmium Releases to Air and Water from Base Metal Smelting Sector.

Table 5.4

Lead

Summary of Lead Releases to Air and Water and Off-site Transfers from Base Metal Smelting Sector (tonnes).

Year	1988				1993				1995				2000 Projections			
Facility	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers
Cominco	117.0	258.0	375.0	NA	83.0	164.0	247.0	0.0	102.7	56.3	159.0	0.0	45.0	20.0	65.0	0.0
Sherritt	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hudson Bay	254.0	0.0	254.0	NA	521.6	0.0	521.6	0.0	30.6	0.0	30.6	0.0	25.4	0.0	25.4	0.0
Inco Thompson	2.0	1.2	3.2	NA	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0
Falconbridge Kidd	10.2	0.8	11.0	NA	9.8	0.8	10.6	0.0	10.2	0.0	10.2	0.0	3.3	0.0	3.3	0.0
Falconbridge Sudbury	20.9	0.5	21.4	NA	20.9	0.0	20.9	0.0	16.6	0.0	16.6	0.0	10.4	0.0	10.4	0.0
Inco Copper Cliff	133.0	0.0	133.0	NA	111.9	0.1	112.0	0.0	84.3	12.0	96.3	0.0	84.3	12.0	96.3	0.0
Inco Port Colborne	0.0	0.0	0.0	NA	0.0	0.1	0.1	2.2	0.0	0.1	0.1	0.7	0.0	0.1	0.1	0.0
Tonolli	0.2	0.0	0.2	NA	0.5	0.1	0.6	179.3	2.3	0.1	2.4	226.9	1.0	0.1	1.2	300.0
Noranda Horne	850.0	1.4	851.4	NA	215.7	1.1	216.8	0.0	355.0	0.6	355.6	0.0	250.0	1.0	251.0	0.0
Noranda CEZ	1.5	1.5	3.0	NA	1.5	0.0	1.5	0.0	0.9	0.1	1.0	8.0	0.2	0.1	0.3	0.0
Noranda C.C.R.	5.3	0.4	5.7	NA	0.7	0.0	0.8	0.3	1.3	0.0	1.3	0.5	1.3	0.0	1.3	0.4
Nova Pb	6.0	0.0	6.1	NA	3.8	0.0	3.8	0.0	1.1	0.0	1.1	0.0	1.6	0.0	1.6	0.0
Noranda Gaspe	183.2	0.8	184.0	NA	20.9	1.4	22.3	0.0	17.0	2.0	19.0	0.0	9.0	1.4	10.4	0.0
Noranda Brunswick	56.0	1.3	57.3	NA	21.7	0.4	22.1	0.0	12.2	0.7	12.9	0.0	12.0	0.6	12.6	300.0
Total	1639.3	265.9	1905.2	NA	1012.1	168.1	1180.1	181.8	636.1	72.1	708.2	236.1	445.5	35.4	480.9	600.4

NA: not available

Totals may not add up due to rounding of facility data

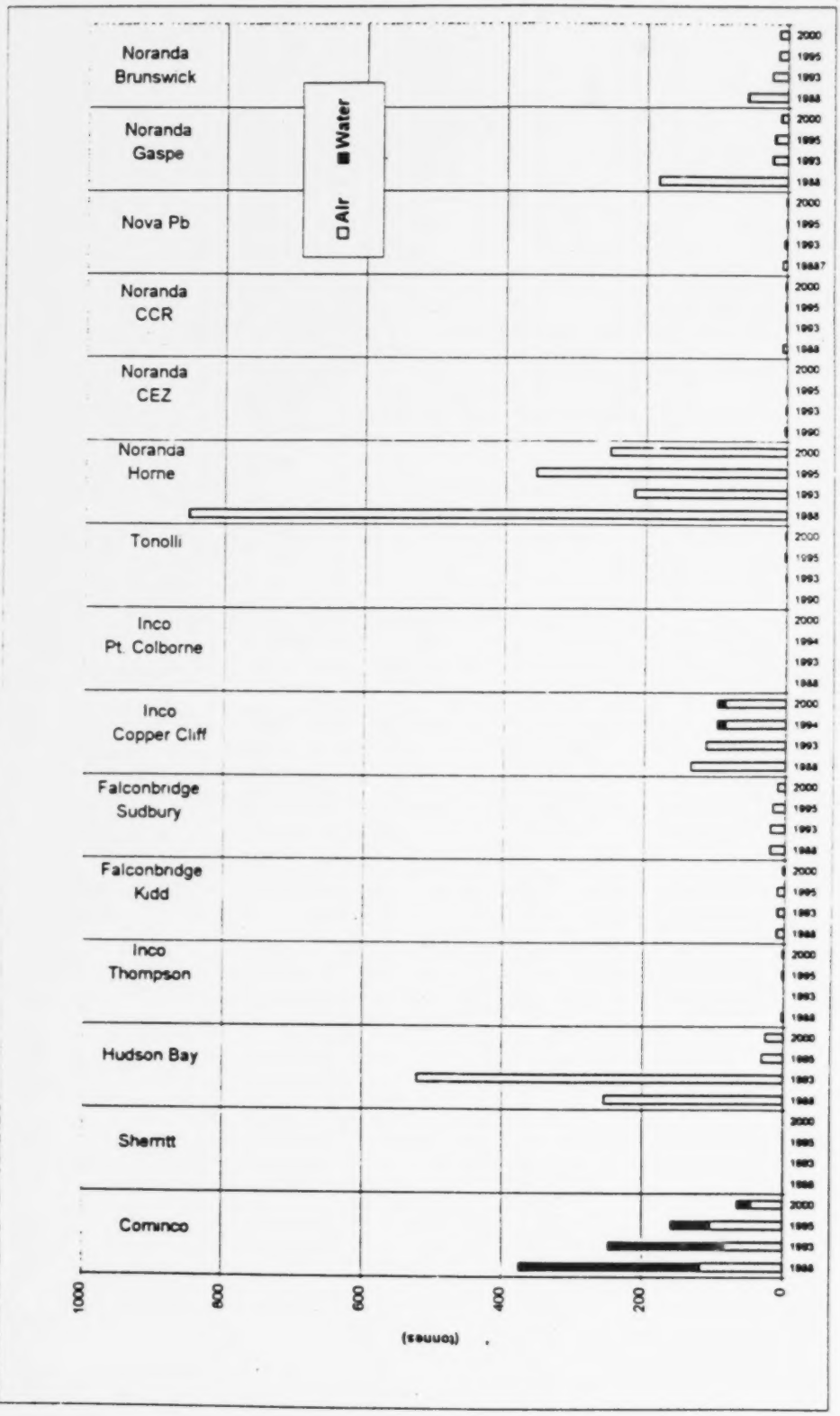


Figure 5.4 Summary of Lead Releases to Air and Water from Base Metal Smelting Sector.

Table 5.5
Mercury
Summary of Mercury Releases to Air and Water and Off-site Transfers from Base Metal Smelting Sector (tonnes).

Year	1988				1993				1995				2000 Projections			
Facility	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers
Cominco	4.16	1.24	5.40	NA	1.60	0.50	2.10	0.00	1.80	0.06	1.86	0.00	0.70	0.15	0.85	0.00
Sherritt	0.00	0.01	0.01	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hudson Bay	19.90	0.00	19.90	NA	7.97	0.00	7.97	0.00	1.80	0.00	1.80		1.80	0.00	1.80	
Inco Thompson	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Falconbridge Kidd	0.01	0.01	0.02	NA	0.01	0.01	0.02	0.00	0.01	0.01	0.02	0.00	0.01	0.01	0.02	0.00
Falconbridge Sudbury	0.60	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.10	0.00	0.10	0.00	0.10	0.00	0.10	0.00
Inco Copper Cliff	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Inco Port Colborne	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tonolli	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Noranda Horne	1.70	0.00	1.70	NA	0.00	0.00	0.00	0.00	0.30	0.00	0.30	0.00	0.40	0.00	0.40	0.00
Noranda CEZ	0.00	0.02	0.02	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	2.00
Noranda C.C.R.	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	
Nova Pb	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Noranda Gaspe	0.50	0.00	0.50	NA	0.50	0.05	0.55	0.00	0.40	0.01	0.41	0.00	0.20	0.01	0.21	0.00
Noranda Brunswick	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75
Total	26.87	1.28	28.15	NA	10.08	0.56	10.64	0.00	4.41	0.08	4.48	10.00	3.21	0.17	3.38	2.75

NA: not available
Totals may not add up due to rounding of facility data

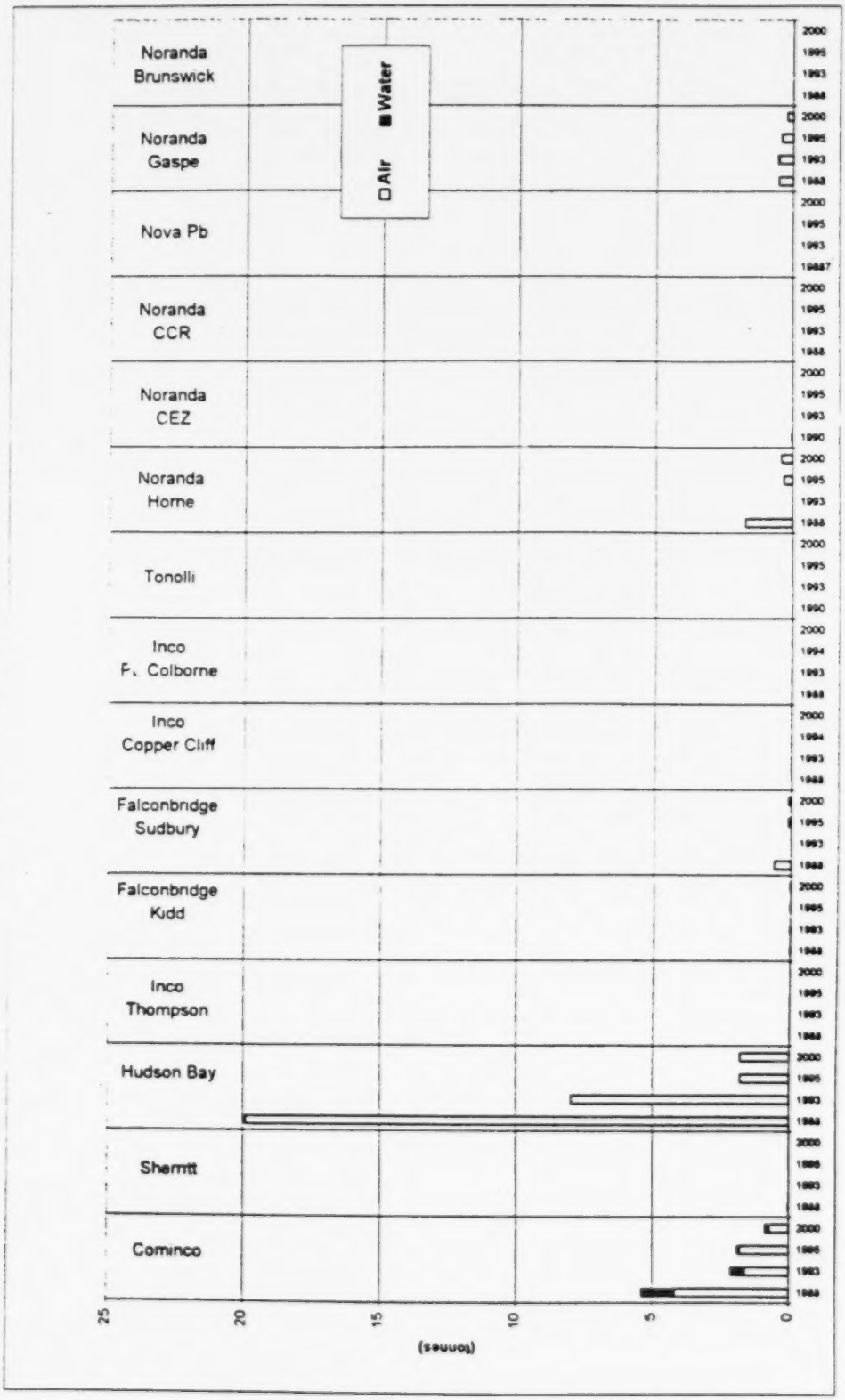


Figure 5.5 Summary of Mercury Releases to Air and Water from Base Metal Smelting Sector.

Table 5.6

Nickel

Summary of Nickel Releases to Air and Water and Off-site Transfers from Base Metal Smelting Sector (tonnes).

Year	1988				1993				1995				2000 Projections			
Facility	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers	Air	Water	Total	Transfers
Cominco	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sherritt	4.8	7.1	11.9	NA	4.9	4.7	9.6	23.0	2.2	1.4	3.6	14.9	1.0	1.0	2.0	7.4
Hudson Bay	4.0	0.0	4.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inco Thompson	318.0	25.5	343.5	NA	149.8	16.6	166.5	0.0	94.7	12.1	106.8	0.0	95.0	15.0	110.0	0.0
Falconbridge Kidd	0.0	0.2	0.2	NA	0.0	0.2	0.2	0.0	0.1	0.2	0.3	0.0	0.1	0.2	0.3	0.0
Falconbridge Sudbury	20.8	6.7	27.5	NA	6.7	1.6	8.3	0.0	5.9	1.8	7.7	0.0	3.0	1.2	4.2	0.0
Inco Copper Cliff	1019.0	0.3	1019.3	NA	334.3	0.6	335.0	0.0	509.7	0.6	510.3	0.0	509.7	0.6	510.3	0.0
Inco Port Colborne	2.3	0.7	3.0	NA	3.0	1.0	4.0	0.0	1.2	0.6	1.8	0.0	0.8	0.6	1.4	0.0
Tonolli	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Noranda Horne	0.0	0.0	0.0	NA	0.7	1.1	1.8	0.0	1.5	0.6	2.1	0.0	3.0	0.7	3.7	0.0
Noranda CEZ	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Noranda C.C.R.	0.3	3.6	3.9	NA	0.0	0.0	0.0	0.2	0.0	0.1	0.1	1.6	0.0	0.1	0.1	1.2
Nova Pb	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Noranda Gaspe	2.8	0.6	3.4	NA	0.9	1.2	2.1	0.0	0.7	1.3	2.0	0.0	0.4	1.1	1.5	0.0
Noranda Brunswick	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1372.0	44.7	1416.7	NA	500.4	27.1	527.5	23.3	616.1	18.7	634.7	16.5	613.0	20.5	633.5	8.6

NA: not available

Totals may not add up due to rounding of facility data

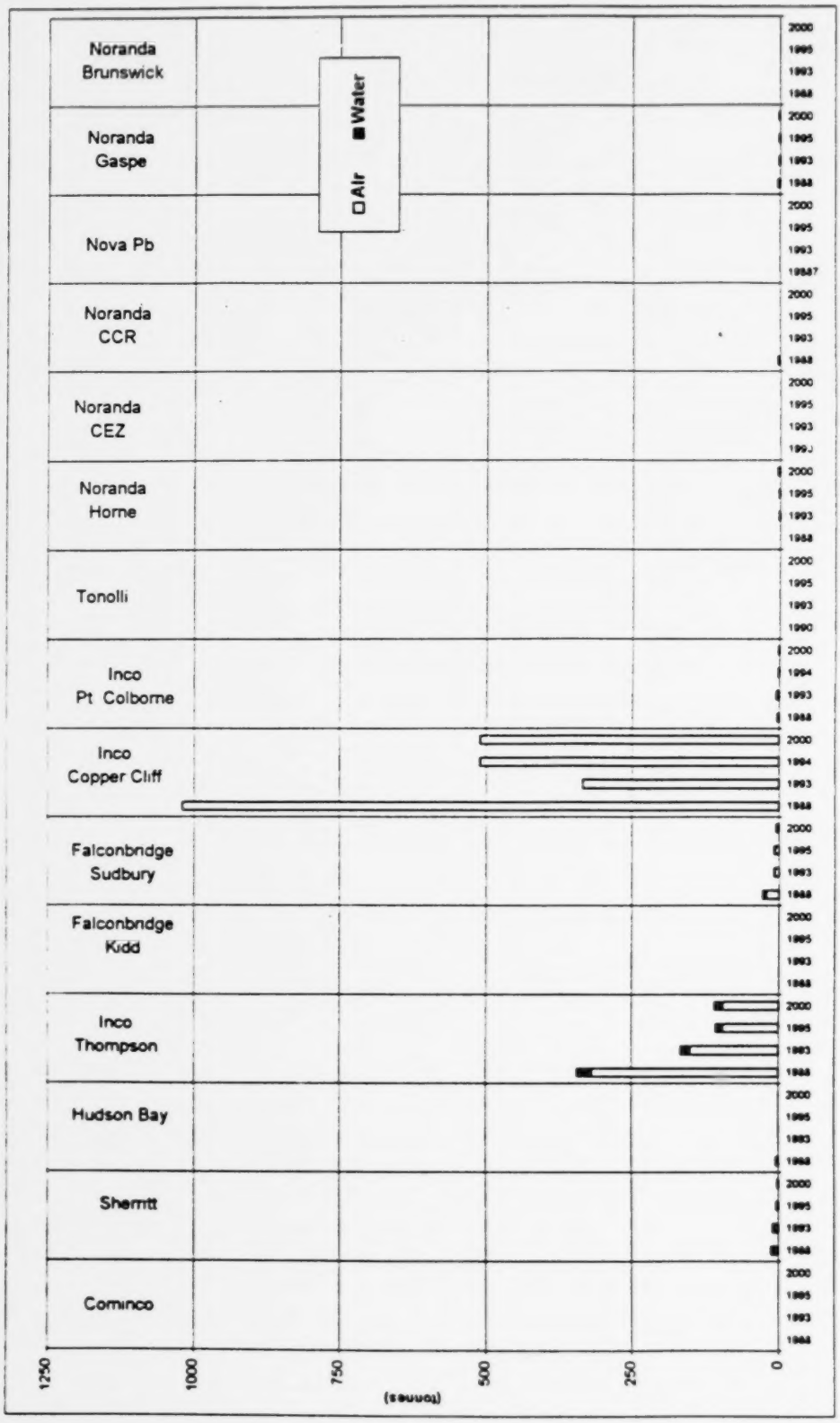


Figure 5.6 Summary of Nickel Releases to Air and Water from Base Metal Smelting Sector.

5.2 Natural Sources

Metallic elements are naturally occurring substances and are widely distributed throughout the earth's crust. As a result, metallic elements are naturally present in soils, plants, food, water and fossil fuels and environmental media. They circulate in the environment as a result of natural sources, including geochemical weathering, forest fires, soil erosion and volcanic activity. Natural Resources Canada has calculated that the top metre of the Canadian land mass contains, as natural background, 20 to 44 million tonnes of arsenic, 2.8 to 5 million tonnes of cadmium, 200 to 370 million tonnes of lead, 1.1 to 2 million tonnes of mercury and 275 to 495 million tonnes of nickel. Estimates of natural emissions of metals to the atmosphere vary widely. Some environmental scientists argue that natural emissions are of minor significance relative to releases arising from anthropogenic activities and conclude that ambient concentrations and human and environmental exposures are primarily due to industrial emissions. Some earth scientists argue that natural releases are significant relative to releases arising from anthropogenic activities and conclude that ambient concentrations are strongly influenced by natural emissions on the local, regional and global scales. The significance of such releases was recognized by the PSL Nickel Assessment report, which indicated that the estimated contribution of natural sources to airborne nickel in 1975 ranged from 595 to 11,200 tonnes (forest fires, volcanos etc). When natural releases are also considered, the contribution by the BMSS has been estimated to be between 5% and 30% of total airborne nickel releases to the Canadian environment.

Bioavailability of natural and anthropogenic emissions influences human and environmental uptake and risks but has not been fully characterized. Metallic elements in geological materials occur primarily in the form of inorganic compounds including sulphides, oxides, chlorides, carbonates and silicates. Some natural processes can mobilize *CEPA* toxic compounds or transform non-toxic forms into *CEPA* toxic forms, while other natural processes including oxidation, precipitation or binding with organic compounds can have the reverse effect by transforming or sequestering potentially toxic substances into more stable, less soluble, and/or less bioavailable forms which are not *CEPA* toxic.

All IT members support the implementation of cost-effective release reduction measures. Industry, Natural Resources Canada, Industry Canada and the Trail Lead Program members suggest that natural releases and bioavailability are factors that should be considered in assessing the expected efficacy and benefits of incremental release reductions at BMSS facilities beyond those that are cost-effective and practicable. They also suggest that it is important for communities and others to consider all possible sources and routes of exposure to toxic substances. In some cases, natural sources have been found to be the cause of elevated levels of these substances in drinking water, food, air and other media. By identifying the most significant anthropogenic and natural sources and routes of concern, communities can prioritize and gain the greatest benefit from management activities.

Environment Canada and Health Canada members suggest that releases of the *CEPA* Substances from the BMSS are additive and avoidable and should therefore be reduced. The Toxics Caucus of the CEN and Canadian Lung Association representatives suggest that releases of the *CEPA* Substances from the BMSS should be eliminated without regard to natural sources and bioavailability. They support this view for the following reasons. First, even though natural sources cannot be eliminated, anthropogenic sources can be controlled through thorough knowledge of industrial processes. As a result, the BMSS industry should attain virtual elimination of these substances, particularly as they have committed to "continuous improvements". "Natural releases" of the *CEPA* Substances should not be constructed as a dominant rationale for anything less than virtual elimination from anthropogenic sources. Secondly, most of the anthropogenic sources are released via large-scale distribution systems, i.e. industry smoke stacks. Through their air emissions, BMSS companies have been releasing metal pollution throughout focused geographic areas, something natural sources tend not to do within the same time frames (with the possible exception of volcanoes and forest fires). Moreover, these focused areas tend to be much more populated than areas subject to releases from natural sources. Thirdly, the precautionary principle promotes prudence, particularly when the pollution of concern includes known or probable human carcinogens. Fourthly, natural background quantities of the *CEPA* Substances have been around for extensive periods of time, if not evolutionary times. This evolutionary background is incomparable to the sudden, large releases by anthropogenic sources throughout the world or the potential dramatic and irreversible changes to those natural evolutionary processes caused by anthropogenic activities. Minute changes in the ecological balance of substances can have a significant negative impact on the environment and human health. Therefore, it would be misleading to suggest anthropogenic sources of the *CEPA* Substances are inconsequential in comparison to the levels of natural sources.

The issues pertaining to the significance of natural and anthropogenic sources, and of bioavailability were not resolved by the IT. All IT members recognize that additional characterization of releases would reduce scientific uncertainty and could improve decision-making.

5.3 Releases of Dioxins and Furans

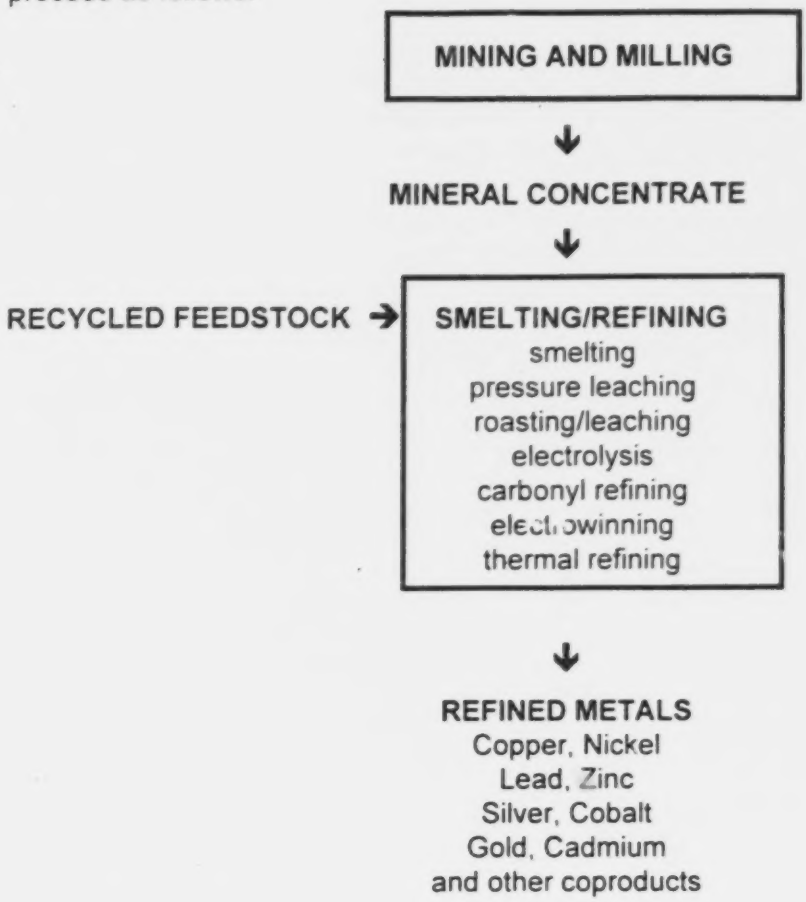
A Federal/Provincial Task Force on Dioxins and Furans is developing a national inventory of releases and an action plan for virtual elimination of dioxins and furans consistent with the federal Toxics Substances Management Policy (See Section 8). Previous studies identified secondary copper refiners and smelters as potential sources of dioxins and furans, but the relevance of these studies to Canadian smelters is unclear because process technology and feed materials were not fully characterized and described. Feed quality, feed preparation methods and process conditions (including gas residence time, oxygen concentration, combustion temperature, flow conditions and heating and cooling rates) can materially affect rates of generation and destruction of dioxins and furans. As a result, release rates and concentrations may vary between smelting processes by orders of magnitude.

The potential for formation of dioxins and furans exists for smelters which have chlorinated plastics or other chlorinated substances in their feeds. Chlorinated plastics are contained in secondary feed materials received by several Canadian smelters. Scrap batteries constitute an important feed source for all Canadian primary and secondary lead smelters, but are mechanically pretreated to separate metals and plastics. The plastic component is separated to the extent practicable for recycling. Mechanical pretreatment can effectively separate metals and plastics contained in wire, but cannot separate copper from printed circuit boards or other electronic scrap. These particular materials constitute an important feed source for Noranda's copper smelter at Rouyn-Noranda, Quebec. Studies conducted by or in the presence of provincial officials at Rouyn-Noranda indicate that even at higher plastics feed rates than usual, combined releases to air and water from point sources would not exceed 0.1 grams per year TEQ (Toxic Equivalent).

6.0 TECHNOLOGIES FOR THE BMSS

6.1 Process Technologies

The technical processes involved in the extraction and refining of base metals generally proceed as follows:



The key metal recovery technologies that are used to produce refined metals are:

- Pyrometallurgical technologies use heat to separate desired metals from unwanted materials. These processes exploit the differences between constituent oxidation potential, melting point, vapour pressure, density, and/or miscibility when melted.
- Hydrometallurgical technologies use differences between constituent solubilities and/or electrochemical properties while in aqueous acid solutions to separate desired metals from unwanted materials; and

- Vapo-metallurgical technologies apply to the Inco Carbonyl Process whereby nickel alloys are treated with carbon monoxide gas to form nickel carbonyl.

Sulphur dioxide may be captured during processing, and can typically be recovered as sulphuric acid when concentrations are above 5 to 7 % SO_2.

Depending upon the origin of the ore or scrap metal and its residual metals content, various coproduct metals such as gold, silver, indium, germanium, cadmium, bismuth and selenium may also be recovered. The processes and technologies employed by the industry are summarized in Table 6.1 and are outlined in greater detail in Appendix 6.

The Canadian BMSS remains in the forefront of metallurgical process development and has benefited from the expertise of academic, government and industrial research and development. The industry continuously introduces new technologies to improve process and environmental performance. This is particularly significant because each facility has unique processes and technologies depending on the minerals being extracted, the nature of the ore and concentrate, the type of scrap, the age of the facility and other factors.

Primary smelting and refining produces metals directly from ores, while secondary smelting and refining produces metals from scrap and process waste. Most primary smelters have the technical capability to supplement primary feed with recyclable materials. Several have done so, where technical, logistical and economic factors were favourable. Examples of scrap feedstock include post-consumer goods such as telephone and computer components, metal parts, bars, turnings, sheets, and wire that is off-specification or worn out. Lead has the largest and most developed recycling component, resulting primarily from the relatively short product life of lead acid batteries and the relative ease with which batteries can be segregated at source for collection and recycling.

Table 6.1: Canadian Base Metal Smelters and Refineries and their Processes and Environmental Control Technologies

	Company	Name of Smelter/Refinery	Major Process Technologies	Major Current Environmental Control Technologies
1	Cominco	Lead Zinc Smelter & Refinery	Blast Furnace Smelting/Sinter Plant/Electrolytic Refining Roast Leach, Pressure Leach, Electrowinning	Electrostatic Precipitator, Baghouse, SO_2 plant and effluent treatment
2	Sherritt	Nickel & Cobalt Refinery	Ammoniac Ammonium Sulphate Pressure Leach	Solid and Liquid Wastes meet environmental standards
3	Hudson Bay Mining & Smelting	Copper Smelter	Hearth Roasting, Reverberatory Smelting	Electrostatic Precipitators, Baghouse
		Zinc Refinery	Pressure Leach Process and Electrowinning	Baghouse, Effluent Treatment
4	Inco	Thompson Nickel Smelter	Fluid Bed Roasters, Converting, Electric Furnace Smelting	Electrostatic Precipitators,
		Thompson Nickel Refinery	Electrorefining	Effluent Treatment
5	Falconbridge	Kidd - Copper Smelter	Mitsubishi Continuous Smelting and Converting Furnace	Electrostatic Precipitators, Acid Plant
		Kidd - Copper Refinery	Electrolytic Refining	Acid Neutralization, Polishing Filtration
		Kidd - Zinc Refinery	Roast-Leach, Pressure Leach, Electrowinning	Electrostatic Precipitators, Wet Scrubbing, Acid Plant, and Effluent Treatment
6	Falconbridge	Sudbury Nickel/Copper Smelter	Fluid Bed Roasting, Electric Furnace Smelting, Converting	Electrostatic precipitators, Acid Plant, Weak Acid Neutralization
7	Inco	Sudbury Nickel/Copper Smelter	Flash Smelting and Converting, Flash Converting (copper) and Finishing Converting	Acid Plant, Electrostatic Precipitators, Wet Scrubbing and Liquid SO_2 Production
		Copper Cliff Copper Refinery	Electrorefining, Leaching and Electrowinning	Effluent Treatment, Iron/Arsenic Removal
		Sudbury Nickel Refinery	Top Blown Rotary Converter (TBRC) Smelting	Electrostatic Precipitators
8	Inco	Port Colborne Cobalt Refinery	Cobalt Refinery	Effluent Treatment, Scrubbers
9	Tonolli	Secondary Lead Smelter	4 Short Body Rotaries	Baghouse, Effluent Treatment
10	Noranda Metallurgy	Horne Copper Smelter	Noranda Process Reactor & Converters	Electrostatic Precipitators, Acid Plant, Effluent Treatment
11	Noranda Metallurgy	Canadian Electrolytic Zinc (CEZ)	Roast Leach Electrowinning	Electrostatic Precipitators, Wet Scrubbing, Acid plant, Effluent Treatment Plant
12	Noranda Metallurgy	Canadian Copper Refinery (CCR)	Electrorefining, Top Blown Rotary Converter (TBRC)	Effluent Treatment, Baghouses, and Wet Scrubbing Systems
13	Nova Pb	Secondary Lead Smelter	Rotary Kiln	Baghouse, Effluent Treatment
14	Noranda Mining & Exploration	Mines Gaspé Copper Smelter	Reverberatory Furnace/Converting	Electrostatic Precipitators, Acid Plant, Effluent Treatment
15	Noranda Mining & Exploration	Belledune Lead Smelter	Sinter Plant/Blast Furnace Smelting/Thermal Refining	Acid Plant, Several baghouses, electrostatic precipitators, wet scrubbing wastewater treatment

6.2 Technical Options to Reduce Releases of the *CEPA* Substances

Hatch Associates Ltd. was retained by Environment Canada to provide advice to the Issue Table concerning technical options that could reduce releases of *CEPA* substances from the BMSS. The consultants first identified generic options as follows:

Generic Options for Reducing Air Emissions

- Improve Environmental Management and Operating Practices
- Improve Existing Gas Cleaning System
- Install Dry Gas Cleaning Equipment
- Install Fugitive Emission Control
- Install Wet Gas Scrubbing Equipment
- Install Acid Plant
- Reduction at Source through Improvements to Existing Process or Equipment
- Modernize Process Equipment, combined with State-of-the-Art Gas Processing
- Change Feed Stock
- Other

Generic Options for Reducing Wastewater Releases

- Improve Environmental Management and Operating Practices
- Improve Existing Wastewater Treatment Systems
- Install New Wastewater Treatment Technology
- Increase Amount of Wastewater Recycled
- Other

The consultants then completed a preliminary assessment of the applicability of each generic option at every site, based on best available information relating to process information, site-specific release points, current site-specific plans, commitments for further release reductions, and best professional judgement. The purpose of this assessment was to provide a preliminary indication of potential release reductions (see Table 6.2), and to identify possible scenarios that could further reduce releases (see Table 6.3).

The scope of the study did not include site visits. The consultants were therefore unable to review in detail the systems currently in place at each site. As a result, the selected options are not necessarily optimal nor the most cost-effective and the detailed requirements for implementation were not assessed. The selected options identify potential release reduction scenarios that could be further evaluated on a site-specific basis. Further studies would be required to refine the potential release reductions. The scope of the evaluation did not include considerations pertaining to project feasibility, including the health or environmental benefits that might be achieved, the expected operating costs or the social and other economic impacts that might be associated with the implementation of a selected option at a particular smelter. These site-specific factors should be considered by regulators, smelter operators, communities and other stakeholders in assessing release reduction scenarios and developing site-specific release reduction plans.

Generic options for reducing air emissions and wastewater releases from each of the facilities participating in the BMSS SOP are outlined in Table 6.3. For each of the generic options at each facility, the consultants established whether that option was already in place or planned. Where a particular option was not already in place or planned, the consultant determined whether or not that option was likely to be technically applicable.

Hatch Associates also established the likely range of release reduction that might be expected from current levels and the likely range in capital cost. They then selected the options that were considered to be the most plausible scenarios.

Details of these assessments are presented in the Hatch Report (see Bibliography). The wide ranges in possible release reductions and capital cost identified in the Hatch Report reflect the uncertainty in the estimates, but provide a possible basis for prioritizing release reduction opportunities and scenarios.

For the purpose of this preliminary assessment and overview, releases of all the *CEPA* Substances from a particular facility have been aggregated. More detailed technical evaluation of scenarios for reduction of releases from a particular site should be guided by site-specific priorities for release reduction, since the relative contribution from each source at a particular facility, the expected release reductions that could be achieved for a particular source and technology, and the capital cost all vary according to the substance of concern.

On the basis of this information, the Issue Table concluded that some technical options exist that could result in the further reduction of releases from the base metal smelting sector beyond the year 2000, as outlined in Table 6.3.

Table 6.2 **Total 1988, 1993, 1995 Releases of As, Cd, Pb, Hg, Ni; Reductions by 2000 and Selected Reductions Scenario Beyond 2000.**

Year	1988	1993		1995		2000		Beyond 2000 (1)		
Facility	tonnes released	tonnes released	% reduction	tonnes released	% reduction	tonnes released	% reduction	tonnes reduced (3)	tonnes released	% reduction
Cominco	449.7	285.7	36.5%	194.6	56.7%	75.0	83.3%	7.5	67.5	85.0%
Sherritt	12.0	9.6	20.4%	3.6	70.2%	2.0	83.4%	1.0	1.0	91.7%
Hudson Bay	376.1	623.8	-65.9%	42.8	88.6%	37.0	90.2%	10.0	27.0	92.8%
Inco Thompson	367.5	173.7	52.7%	114.3	68.9%	118.0	67.9%	59.0	59.0	83.9%
Falconbridge Kidd	19.6	17.4	11.1%	16.9	13.7%	6.0	69.2%	0.6	5.4	72.3%
Falconbridge Sudbury	63.1	35.0	44.5%	30.0	52.5%	17.6	72.1%	8.8	8.8	86.1%
Inco Copper Cliff	1187.3	457.7	61.4%	616.1	48.1%	616.1	48.1%	308.1	308.1	74.1%
Inco Port Colborne	3.0	4.1	-39.2%	1.9	35.3%	1.5	50.0%	0.1	1.3	55.0%
Tonolli (2)	0.2	0.6		2.4		1.2		NA	NA	NA
Noranda Horne	1005.5	249.6	75.2%	397.1	60.5%	286.9	71.5%	195.7	91.2	90.9%
Noranda CEZ	4.7	1.9	59.0%	2.0	58.3%	0.4	91.3%	0.04	0.4	92.2%
Noranda C.C.R.	19.2	1.4	93.0%	1.6	91.6%	1.6	91.8%	0.2	1.4	92.6%
Nova Pb (2)	6.2	4.0		1.3		1.8		NA	NA	NA
Noranda Gaspe	244.1	44.8	81.6%	38.2	84.3%	20.7	91.5%	10.3	10.3	95.8%
Noranda Brunswick	67.6	31.5	53.3%	18.2	73.1%	17.5	74.2%	1.7	15.7	76.7%
Total	3825.8	1940.9	49.3%	1480.9	61.3%	1203.3	68.5%	603.1	597.2	84.4%

NA: not available

(1) Selected reductions scenarios beyond 2000 are based on assumed technical options for various facilities based on a report "Base Metal Smelting Sector Strategic Options Study" dated March 31, 1997, prepared by Hatch Associates Ltd. for Environment Canada and subsequent release inventory modifications .

(2) Data shown in 1988 column for Nova Pb is 1989 data and for Tonolli is 1990 data; the data are not directly comparable to later years, and thus no % reduction is shown.

(3) Tonnes Reduced Since 2000

(4) All Columns Showing " % Reductions " are from the 1988 base year.

(5) A minus sign (-) in front of % reduction indicates an increase in amount released.

Table 6.3 ***CEPA* Substances: Possible Reduction Options beyond 2000 Derived from the Hatch Report**

Facility	Summary of Technical Reduction Options beyond 2000*
Cominco	Continuous Improvements; Fugitive emission controls from materials handling & transportation by physical linking of new smelter plants; Recycling of effluents; Updating materials management plan
Sherritt	Continuous Improvements; Fugitive dust emissions controls; Total treatment/recycling of effluents.
Hudson Bay	Continuous improvements; Scrubber for roaster off-gas; Scrubber for all stack streams; Acid plant; (with smelter modifications); Continuous smelting to replace roasting and reverberatory smelting; Custom feed choices; Reuse zinc plant electrostatic precipitator; Improve separation of minerals at milling/concentration stage to reduce cadmium & mercury; Fugitive emissions controls.
Inco Thompson	Continuous improvements; Smelter electrostatic precipitator upgrade and other gas cleaning equipment; Flash furnace to replace roasting and electric furnace; Scrubbers for off-gases; Acid plant for off-gases (smelter modifications required); Fugitive emissions controls.
Falconbridge Kidd	Continuous improvements; Scrap melting off-gases to baghouse; Scrubbers on zinc and copper concentrate dryer off-gases; Changes to converting furnace to allow reintroduction of spent copper anodes; Hydrometallurgy for all zinc; Fugitive emissions controls.
Falconbridge Sudbury	Continuous improvements; Scrubber on electric furnace and converter off-gas streams; Upgrade to furnace #2; Improve hooding to reduce air in-leakage to concentrate gas stream; Furnace and converter off-gases to acid plant (modifications required); Effluent recycling/treatment; Fugitive emissions controls; Continuous converting
Inco Copper Cliff	Continuous improvements; Scrubber for converter, roasting and finishing off-gases; Fluidized bed roaster off-gas to acid plant; Baghouse to treat anode refining off-gas (copper refinery); Scrubber on TBRC smelting off-gas (nickel refinery); Fugitive emissions controls.
Inco Port Colborne	Continuous improvements;
Tonolli	Continuous improvements; CX-EWS process assessment
Noranda Horne	Continuous improvements; Electrostatic precipitator upgrade; Desulphurization furnace and anode furnace off-gases through baghouse; Scrubbers for desulphurization furnace and anode furnace off-gases; Desulphurization furnace removal; Fugitive emissions controls.
Noranda CEZ	Continuous improvements.
Noranda CCR	Continuous improvements
Nova Pb	Continuous improvements; Afterburner dual baghouse
Noranda Gaspe	Baghouse to treat anode refining off-gas; Scrubber for reverberatory and anode furnace off-gases; Reverberatory furnace off-gas to acid plant; Reverberatory furnace shutdown; Reverberatory furnace and Pierce-Smith converter replacement with continuous reactors; Fugitive emissions controls.
Noranda Brunswick	Continuous improvements; Kivcet process; Gas cleaning system improvement; Fugitive emissions controls.

*Summary of options derived from Hatch Report Base Metal Smelting Sector Strategic Options Studies for Environment Canada, March 31, 1997.
Not all options are necessarily compatible with each other. Site specific studies are required to determine technically and economically feasible options.
Continuous improvement is defined here as any, all or a combination of technical options including improvement of management and operating practices.

Certain facilities employ currently available state-of-the-art process and pollution control technology and management practices or are in the process of implementing such technology. Releases from these facilities are now or will be low relative to other sources by the year 2000. Some incremental release reductions beyond the year 2000 for these facilities are achievable with continual improvement. Further release reductions would be possible only with the longer term development, demonstration and implementation of new technology.

Certain other facilities employ currently available state-of-the-art pollution control technology and management practices or are in the process of implementing such technology. Releases from these facilities are also low relative to other sources. Incremental release reductions beyond the year 2000 for these facilities are achievable with continual improvement. Further release reductions beyond the year 2000 for these facilities would be technically possible with major new investments in currently available state-of-the-art process technology. The economic and technical feasibility of such investments and the resulting social and economic impacts were not examined by Hatch Associates or by the Issue Table.

Other facilities do not employ currently available state-of-the-art process or pollution control technology and management practices and are not in the process of implementing such technology. Releases from these facilities are generally higher relative to other sources. While incremental release reductions beyond the year 2000 for these facilities are achievable with continual improvement, significant release reductions beyond the year 2000 for these facilities would be technically possible with new investments in currently available state-of-the-art pollution control technology or with major new investments in currently available state-of-the-art process technology. The technical and economic feasibility of such investments and the resulting social and economic impacts were not examined by Hatch Associates or by the Issue Table. These site-specific factors and the health and environmental benefits that might be realised could be addressed by regulators, smelter operators, communities and other stakeholders in considering release reduction scenarios and developing site-specific release reduction plans.

7.0 POLICY INSTRUMENTS FOR MANAGING *CEPA* SUBSTANCES

7.1 Introduction

This section provides a description of various policy instruments that could be used to manage the *CEPA* Substances of concern to this SOP. This section also provides some suggested criteria that may be useful in considering the appropriate mix of policy instruments to achieve an effective and efficient management framework for the *CEPA* Substances.

7.2 Policy Instruments and their Implementation Mechanisms

Environmental decision-makers have a number of policy instruments that could be employed to manage toxic substances. Moreover, various mechanisms can be used to implement the appropriate mix of policy instruments in order to achieve environmental policy objectives. These mechanisms have been loosely categorized as "regulatory" and "non-regulatory" implementation mechanisms. However, the mechanisms used to implement policy instruments may be better viewed as a continuum between two poles. At one end, is a "formal and mandatory" (regulatory) approach, while at the other end is an "informal and voluntary" (non-regulatory) approach. A range of implementation mechanisms is available between these two poles. Many policy instruments occupy a relatively fixed position on the continuum. For example, most government-introduced, market-based policy instruments are implemented by regulation. However, many policy instruments are more fluid, occupying a location on the continuum that depends upon the degree to which decision-makers feel that an environmental policy objective should be supported by the force of law. Moreover, a policy instrument can occupy more than one place along the continuum. For example, targets and schedules for reducing the release of toxic substances could be promoted as a self-imposed voluntary initiative by a single company and/or through command-and-control provisions in a federal or provincial law with appropriate penalties for non-compliance.

The IT identified several policy instruments that might be relevant to their deliberations, including the following:

- reduction/elimination targets and schedules;
- environmental performance standards (including standards for releases to air and water);
- environmental guidelines/codes of practice;
- pollution prevention plans/environmental management plans (EMPs);
- covenants;
- market incentives and disincentives (including tradeable emission, deposit-refund schemes, low interest or forgivable loans, and tax deductions or credits);

- environmental liability;
- technology assistance (including training and education); and
- information generation, compilation and distribution.

The IT also looked at the mechanisms for implementing an appropriate mix of these policy instruments. Generally, the IT agreed that the "regulatory" implementation mechanism includes "command-and-control" regulations that prescribe specific performance standards or reduction targets and schedules and imposed penalties for non-compliance. As well, the regulatory mechanism could promote the development of model pollution prevention plans or environmental codes of practice and guidelines, non-compliance with which would not lead to legal sanctions. The IT also identified "non-regulatory" implementation mechanisms that include voluntary initiatives where an individual company or an association implements a self-imposed program to reduce or eliminate pollution or a voluntarily negotiated initiative developed in partnership with government, industry and the public sector. The Accelerated Reduction/Elimination of Toxics program is an example of a voluntarily negotiated initiative.

The IT also discussed the role of covenants. A covenant is an example of a policy instrument that is relatively fixed in the mid-range of the implementation mechanism continuum. Covenants are voluntarily negotiated agreements involving a number of parties, including governments, industry and public interest participants. Negotiations are transparent and are used to determine the most appropriate means for reducing/eliminating identified substances. While entering into a covenant is voluntary in nature, the covenant itself has the status of a legally binding contract in civil (private) law. Moreover, the covenant cannot alter a participant's obligations under federal, provincial or municipal law.

7.3 Screening Criteria

The IT identified several screening criteria, which to a greater or lesser extent, could be used to assess mixes of policy instruments and implementation mechanisms, as follows:

- environmental effectiveness;
- cost-effectiveness and competitiveness;
- incentives;
- compliance, including enforceability;
- growth;
- speed;
- fairness;
- intrusiveness and flexibility;

- data requirements;
- compatibility; and
- public acceptability.

Section 9, detailing the Recommendations, presents the views of IT members on the appropriate mix of policy instruments and implementation mechanisms needed to effectively manage the *CEPA* Substances of concern to this SOP. However, the IT had neither the appropriate resources nor the time to evaluate its recommendations against these criteria. Moreover, the IT recognizes that the screening criteria, in and of themselves, are susceptible to various interpretations and may be somewhat controversial.

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8.0 CURRENT POLICY AND REGULATORY FRAMEWORK

8.1 Introduction

Several policy and regulatory instruments are currently used to manage the *CEPA* Substances. This section describes this framework. In large part, the fundamental question that the IT had to address was the extent to which the current framework adequately manages the *CEPA* Substances to minimize human and environmental impacts. The next section, detailing the Recommendations of the IT, presents the views of IT members concerning the extent to which the current framework can be improved. The IT recognizes that the current management framework must operate within a broader context that includes regional and national environmental laws and policies that influence the management of toxic substances generally. Note that the policy instruments outlined in Section 8.2 include both regulatory and non-regulatory initiatives.

8.2 Current Policy Framework

8.2.1 The Federal Toxic Substances Management Policy (TSMP)

The federal TSMP (1995) establishes criteria and separate goals for the management of toxic substances, as follows:

TSMP GOALS FOR TRACK 1 AND TRACK 2 SUBSTANCES

	Criteria	Management Objectives
Track 1	• *CEPA*-toxic or *CEPA*-toxic equivalent, • Predominantly Anthropogenic, • Bioaccumulative, and • Persistent.	Virtual Elimination from the Environment
Track 2	Not all Criteria Met	Life-Cycle Management to Prevent or Minimize Releases

The actual numerical and narrative criteria are explained in the TSMP. Using the criteria of the TSMP, Environment Canada has determined that several substances, including dioxins and furans are candidate Track 1 substances. The confirmation of their status as Track 1 substances will take place during the summer 1997, after the on-going public comment period.

For Track 1 substances the long-term goal is virtual elimination. The TSMP states that virtual elimination is based on strategies to prevent the measurable release of the substances into the environment. In cases where a Track 1 substance cannot be successfully managed throughout its life-cycle in a manner that prevents its measurable release into the environment, the generation or use of that substance will be phased out. The onus remains on those who generate or use a Track 1 substance to demonstrate that the substance will not be released into the environment in measurable concentrations at any point in its life-cycle. The ultimate objective of eliminating a Track 1 substance from the environment is set irrespective of socio-economic factors. Nevertheless, management plans, including targets and schedules to achieve that long-term objective, will be based on analyses of environmental and human health risks as well as social, economic and technical considerations.

Substances that do not satisfy all four criteria for Track 1 management are candidates for full life-cycle management to prevent or minimize their releases into the environment. Naturally occurring substances, elements or radionuclides are not candidates for Track 1. However, when warranted, a natural substance that is used or released as a result of human activity may be targeted for reduction to naturally occurring levels under Track 2. Risk assessment and risk management approaches will be used to identify Track 2 substances and management options. Management strategies, including pollution prevention, pollution control, remediation, and, in the case of sources outside Canada, international action, will be based on a life cycle approach. However, pollution prevention is often the most cost effective management strategy and in such cases will be promoted by the federal government as the preferred approach for Track 2 substances. A Track 2 substance in the environment as a result of human activity relating to specific products, uses or releases may be targeted for virtual elimination from the environment if it poses unacceptable risks to the environment or human health. Under the TSMP, inorganic arsenic compounds, inorganic cadmium compounds, lead, mercury, and oxidic, sulphidic and soluble inorganic nickel compounds are Track 2 substances.

8.2.2 The Federal Pollution Prevention Strategy

"Pollution Prevention: A Federal Strategy for Action" (1995) describes the federal government's environmental protection policy in a sustainable development context. It defines pollution prevention as the use of processes, practices, materials, products or energy that avoid or minimize the creation of pollutants and waste, and reduce overall risk to human health or the environment. The federal strategy identifies pollution prevention as often the most effective approach for protecting the environment. The Pollution Prevention Strategy promotes an action plan involving partnerships in five key areas - within the federal government, with other governments, with the private sector, with individual Canadians, and with the international community. Its focus is on achieving environmental results through new legislation, more efficient regulation, voluntary initiatives and economic instruments.

8.2.3 The Canadian Council of Ministers of the Environment (CCME) Pollution Prevention Implementation Strategy

In "A Strategy to Fulfill the CCME Commitment to Pollution Prevention" (1996), the CCME has adopted its mission statement as follows:

- To collectively shift Canada from being a society that attempts to manage pollutants and waste after they have been created toward one that does not create them in the first place; and
- To have pollution prevention principles and practices incorporated into decisions made at all levels of Canadian society.

The goal of the CCME as outlined in the Strategy is to make pollution prevention the strategy of choice for protecting the environment and improving economic competitiveness.

8.2.4 The Minerals and Metals Policy

"The Minerals and Metals Policy of the Government of Canada: Partnerships for Sustainable Development" (1996) describes, within areas of federal jurisdiction, the Government's role, objectives and strategies for the sustainable development of Canada's mineral and metal sources.

The policy enunciates a number of principles for sustainable development-based decision-making, including:

- a responsive public policy framework;
- the role of the market mechanism;
- the role of regulation;
- the role of non-regulatory approaches;
- the importance of science;
- endorsement of the concept of pollution prevention;
- affirmation of the precautionary principle; and
- recognition of the "polluter pays" principle.

The Policy represents an important source of guidance for federal decisions on minerals and metals in the context of sustainable development. For example, the Policy:

- sets parameters for federal decisions on minerals and metals, including a recognition of the need for sound science, the importance of global markets, and the benefits of both regulatory and non-regulatory approaches in pursuing environmental protection;
- commits the Government to continued efforts to secure international mineral investment for Canada and notes the importance of a fiscal and tax environment that recognizes the special challenges of the industry and its global context;
- enunciates the Government's support of the principle of safe use of minerals and metals and engages the Government to advance this principle both domestically and internationally; and
- encourages the minerals and metals industry to continue to assume greater responsibility for environmental performance wherever it operates, and to be a steward for minerals and metals throughout their life cycle in a manner that is transparent and, when possible, measurable.

8.2.5 The Canada-Ontario Agreement (COA)

The Canada-Ontario Agreement respecting the Great Lakes Ecosystem, as amended in 1994, provides the framework for strategic coordination of shared federal and provincial responsibility for environmental management in the Great Lakes Basin. The prevention and control of pollution is one of the three main objectives of the COA and is particularly relevant to the BMSS SOP. The three commitments of COA that relate specifically to the prevention and control of the *CEPA* Substances released by the BMSS are:

- to seek a 90% reduction in the use, generation or release of Tier I substances by the year 2000, with the ultimate goal of virtual elimination. The Tier I substances include dioxins, furans, mercury and alkyl lead;
- to collaborate and provide support for voluntary programs for industry and others to reduce the use, generation or release of Tier II substances and establish specific time lines and targets for achieving their virtual elimination. The Tier II substances include cadmium; and
- to promote and encourage pollution prevention programs for other pollutants and hazardous wastes.

The COA emphasizes voluntary and cooperative initiatives by responsible parties to achieve reductions in the use, generation or release of Tier I and Tier II substances.

8.2.6 St. Lawrence Vision 2000

In 1988, the governments of Canada and Quebec signed a co-operative agreement to harmonize their efforts to safeguard the St. Lawrence River. The St. Lawrence Action Plan, a five-year program, was signed in 1989. St. Lawrence Vision 2000 (SLV 2000) was signed in 1994 to carry on the work of the Action Plan, but with more of an ecosystem approach.

One of the seven components of SLV 2000, the Protection component, continues the Action Plan objective of reducing by 90% the toxic discharges of 50 industrial plants established along the St. Lawrence River and the Saguenay River. Another 56 priority plants have been added to the list and the aim is the virtual long-term elimination of 11 persistent and bioaccumulative toxic substances.

8.2.7 Accelerated Reduction/Elimination of Toxics (ARET)

Launched in 1991, the ARET program aims at reducing or eliminating toxic substance emissions through voluntary initiatives. During preliminary deliberations, a multi-stakeholder group comprised of government, business, labour, environmental NGOs and health and professional groups reached consensus on (a) criteria for identifying toxicity, and (b) the categorization of target substances into five lists. However, ENGO and labour representatives withdrew from the ARET committee in 1993 due to continuing differences among stakeholders regarding the priority to be placed on the reduction versus the elimination of targeted substances and on regulatory versus voluntary means for achieving this. The remaining stakeholders issued the "ARET Challenge" in March 1994. For substances placed in List A-1 (those which meet or exceed criteria for toxicity, bioaccumulation and persistence), the ARET vision is the virtual elimination of discharges into the environment from human activities, with a 90% reduction by the year 2000. PCBs, 2,3,7,8-TCDD (dioxin), 2,3,7,8-TCDF (furan), and methyl mercury are all substances on List A-1 that are relevant to the BMSS IT. The reduction target for cadmium was established at 50% by ARET members.

List B-2 includes substances that meet or exceed criteria for persistence and toxicity. For these substances, the ARET vision is reduction of discharges to levels that are insufficient to cause harm, with a short-term reduction of 50% by the year 2000. The substances of interest to the BMSS IT that are included on List B-2 are arsenic (inorganic), lead (all forms except alkyl), mercury (elemental and inorganic), and nickel (inorganic, respirable, soluble).

Within the Mining Association of Canada, 13 mining and smelting companies have submitted action plans in response to the "ARET Challenge". ARET/MAC members that support ARET are responsible for 92% of base metal production in Canada. Specific data on the major releases of ARET-listed substances by the smelting sector are presented in Section 5 of this Report.

8.3 Current Regulatory Framework

Releases to water are controlled through a variety of federal and provincial mechanisms. Subsection 36(3) of the federal *Fisheries Act* prohibits the deposit of a deleterious substance into waters frequented by fish unless authorized by a regulation. This provision has been interpreted by the Courts and regulators alike to prohibit release of a liquid effluent that is acutely lethal to fish. Some primary base metal smelters or refineries may also be subject to the *Metal Mining Liquid Effluent Regulations* under the *Fisheries Act* or to the associated *Guidelines for the Control of Liquid Effluents from Existing Metal Mines* if the effluent from the smelter or refinery is combined with the effluent from an active mine or mill.

Provinces have developed mechanisms to exercise control over water resources and protect the aquatic environment and have in some cases delegated authority to certain municipalities. The specific regulatory mechanisms and requirements differ between facilities and among provinces and include legally enforceable limits for pH and metal concentrations as well as procedures for sampling, analysis and reporting and may include requirements for ambient environmental effects monitoring and ambient environmental quality. Site specific requirements are typically implemented through a site specific permit, approval or license.

Cominco, Noranda Brunswick, Nova Pb and Tonolli produce lead by processing smelter feed materials that include lead-bearing materials other than lead concentrates derived from a primary mining operation. These facilities therefore fall within the regulatory definition of a "secondary lead smelter" and are subject to the *Secondary Lead Smelter Release Regulations* (*SLSRRs*) under *CEPA*. The *SLSRRs* establish legally enforceable concentration limits for air emissions of lead in particulate matter, as well as procedures for sampling, analysis and reporting.

All provinces within which BMSS members operate have regulatory requirements to control air emissions. Some of these limit concentrations or loading of particulate emissions at source. Others have site-specific requirements based on point of impingement ambient air quality criteria, or have general air quality criteria for specific substances. Except for the *SLSRRs*, there are no federal or common provincial standards applicable to all members of the BMSS to limit the releases of the *CEPA* Substances at source.

9.0 Recommendations

9.1 Release Reduction Targets and Schedules - Recommendation No.1

Companies from the BMSS have committed on a voluntary basis to surpass the ARET Program targets, and to reduce total releases of the *CEPA* Substances[6] from 1988 levels by approximately 70% by 2000. **It is recommended that total releases of the CEPA Substances from the BMSS should be reduced from 1988 levels by 80% by the year 2008 and by 90% beyond 2008 through the application of technically and economically feasible methods.**

While the substance reduction targets are aggregated, it is understood that the *CEPA* Substances will be reported on an individual facility and substance basis, with the expectation that companies will make best efforts to achieve reductions for the individual *CEPA* Substances that are consistent with overall targets, taking into account process and control technologies, opportunities for continuous improvements in environmental performance, provincial requirements, and local needs and priorities.

Progress towards achieving these release reduction targets and schedules will be publicly reported annually through the NPRI and ARET programs, with a review in 2001 and 2009 with regard to attainment of these targets and the need to establish revised targets and schedules. (See Recommendation 10)

The IT recognizes that release reduction targets and schedules for particular substances and facilities will continue to be influenced by other policy frameworks, including the Canada-Ontario Agreement and the St. Lawrence Vision 2000.

The Toxics Caucus of the CEN disagrees with this recommendation because it ignores the goal of virtual elimination, is based upon a voluntary initiative, and adds little to already established goals of the industry. Moreover, the base year for comparing release reductions should be 1994 when the federal SOP commenced, instead of 1988, and the proposed reductions apply only to air and water releases and not to all media. As a result, the Toxics Caucus of the CEN recommends that the goal of the industry should be to virtually eliminate releases of *CEPA*-toxic and Schedule 1 substances as soon as possible, but no later than 2017. In the meantime, the industry should be required to adopt the COA and SLV 2000 commitments as interim reduction targets, including the following:

[6]As detailed in Section 1, the "*CEPA* Substances" addressed in these Recommendations are inorganic arsenic compounds, inorganic cadmium compounds, dioxins and furans, lead, mercury, and oxidic, sulphidic and soluble inorganic nickel compounds. However, the recommended release reduction targets and schedules are for total metal releases. Dioxins and furans are dealt with separately in Recommendation No.7.

- reduce cadmium released by 90% from 1994 levels by 2000;
- reduce dioxin and furan releases (if released by smelters) by 90% by 2000; and
- reduce the remaining pollutants by 50% from 1994 levels by 2002, and by 90% by 2010.

According to the Toxics Caucus of the CEN, the virtual elimination goal and the interim targets should apply to each facility and each substance for all releases and transfers and should be implemented through pollution prevention plans mandated by a *CEPA* regulation.

9.2 Environmental Standards[7] - Recommendation No.2

It is recommended that the Canadian Council of Ministers of the Environment (CCME) in cooperation with the CEPA Federal-Provincial Advisory Committee (FPAC) continue their efforts to develop Canada-wide environmental ambient air and water quality guidelines for substances of relevance to the BMSS.

It is recommended that CCME develop appropriate environmental source performance guidelines for discharges to air and water, taking into account best available pollution prevention techniques and control technologies economically achievable for new and for existing smelters. These guidelines should be developed as soon as practicable but not later than the year 2000.

It is recommended that CCME develop protocols for the measurement and reporting of releases to promote consistent approaches to source sampling, analysis, release estimation and reporting, while retaining the flexibility to accommodate site-specific environmental needs and priorities.

It is recommended that stakeholders have appropriate opportunities to assist in the development of the CCME environmental guidelines and protocols. Existing standards and protocols implemented by federal or provincial regulations, guidelines, approvals and other mechanisms should be considered, in part to avoid duplication and to improve effectiveness and efficiency. Other initiatives that may influence the development of the CCME guidelines and protocols, including the proposed Canada-wide Accord on Environmental Harmonization and the Environmental Standards Sub-Agreement to the Accord, the government

[7] "Environmental standards" have been defined in different ways by governments and others. For the purpose of this SOR, IT participants agreed to utilize a definition that was recently developed by the CCME in the draft Canada-Wide Environmental Standards Sub-Agreement: *environmental standards encompass qualitative or quantitative standards, guidelines, objectives and criteria for protecting the environment and human health.*

response to the AQUAMIN[8] initiative, the work of CCME Task Forces on the Development of Ambient Air and Water Quality Guidelines and international developments should also be considered.

The public review in 2001 (see Recommendation No. 10) should be mandated to compare the Environmental Management Plan and the site-specific monitoring results with the CCME environmental source performance guidelines and provide recommendations concerning the need to implement these CCME guidelines through legally enforceable mechanisms.

The IT recognizes that Federal and Provincial governments have the right to exercise their regulatory and non-regulatory authorities within their jurisdictions. The development of the CCME guidelines outlined in this recommendation would not prevent any government from introducing more stringent environmental measures to reflect specific circumstances or to protect environments or environmental values within its jurisdiction. Where governments have been unable to reach consensus on the development of the recommended guidelines, each government is free to act within its existing authority and advise other governments accordingly.

These recommendations were reached only after considerable discussion and compromise and with some reservations on the part of various IT members. IT members urge the Ministers to consider these recommendations accordingly.

The Toxics Caucus of the CEN is skeptical of the CCME involvement in the development of the standards, especially in light of their often-voiced concerns with the CCME harmonization proposals. The Toxics Caucus of the CEN and the Canadian Lung Association (CLA) representatives prefer the immediate development and implementation of legally enforceable standards under a *CEPA* regulation. The CLA and the Toxics Caucus representatives cautioned that the establishment of Canada-wide environmental standards must not be construed as baseline discharge limits, below which discharge concentrations would not be considered to adversely impact on human health or the environment.

9.3 Site-Specific Environmental Management Plans - Recommendation No.3

It is recommended that site-specific Environmental Management Plans (EMPs) be developed and implemented by each BMSS facility in concert with governments, local communities and other affected stakeholders. This recommendation reflects the commitment to environmental management plans expressed by the BMSS representatives at the IT, including the commitment to address in EMPs priorities for

[8]The Assessment of the Aquatic Effects of Mining in Canada (AQUAMIN) was a multistakeholder consultation established to update and strengthen the Metal Mining Liquid Effluent Regulations under the federal *Fisheries Act*. The Final Report was released by Environment Canada in November 1996.

exposure reduction and the attainment of the release reduction targets within the identified timeframes.

Plans may differ in detail and form to suit local circumstances, but will be guided by the priority for pollution prevention, transparency and verified reporting. It is anticipated that guidance on protocols for environmental management planning will emerge from various initiatives currently in progress by government agencies, industry and the International Standards Organization.

For the purposes of this recommendation, the EMP should include the following elements:

- a process for consulting on the development of the Environmental Management Plan with, and reporting progress to, stakeholders;
- a written policy statement reflecting the company's commitment to reduce releases to the environment through pollution prevention, control and remediation, and its commitment to continual improvement;
- as a minimum, an assessment of the *CEPA* Substances released to the environment;
- a review to identify potential reduction options for releases, in consideration of performance benchmarks elsewhere in the industry, and employing pollution prevention methodology, including consideration of changes in process technology, source reduction and good management practice;
- an analysis to identify reduction options that are technically and economically feasible;
- a prioritization process to rank the most feasible options;
- targets and schedules for reduction in the releases of the *CEPA* Substances;
- a monitoring program to track progress towards attainment of the targets, including a system of verification that has the confidence of stakeholders;
- a periodic review of the Environmental Management Plan with respect to effectiveness and continuous improvement.

It is recommended that the effectiveness of this site-specific environmental management planning process be evaluated in 2001 (see Recommendation No.10).

9.4 Consistent Data and Reporting - Recommendation No.4

Public confidence is an important consideration in programs to reduce releases of the *CEPA* Substances. The BMSS currently reports these releases via an assortment of methods including NPRI, ARET, Provincial Ministries of the Environment reports and

other means. These data are available to the public in electronic databases, summary reports, corporate reports and other means. Data collection methods are not all standardized and as a result data from some sources is not consistent and comparable over time.

It is recommended that standard reference methods for release monitoring, quality assurance/quality control programs, and independent verification of the system for monitoring and reporting of data be developed and implemented to support the CCME guidelines (See Recommendations No.2 and No.3).

9.5 Federal-Provincial Cooperation - Recommendation No.5

It is recommended that governments develop a coordinated approach that avoids duplication in the implementation of environmental measures for the BMSS. For example, Environment Canada could explore with the provinces of British Columbia, Manitoba, Ontario, Quebec and New Brunswick the delivery of the *Secondary Lead Smelter Release Regulations* with a view to concluding administrative or equivalency agreements as soon as practicable and not later than 1999.

9.6 Recycling - Recommendation No.6

Given the substantial benefits to Canadians of metal recycling and their inherent recyclability, **it is recommended that the federal government, within its jurisdictional responsibilities and resources, should, among other things:**

- **work with provinces and territories, industry, and other stakeholders to enhance the efficiency and effectiveness of regulations and remove unnecessary impediments to metal recycling; and**
- **encourage development of products that take into account recyclability in their design.**

It is recommended that efforts should continue to identify and address barriers to recycling. Such barriers may include regulatory mechanisms or inequities in the tax system.

The IT notes the efforts currently in progress led by the National Round Table on the Environment and the Economy (NRTEE). This group is discussing in a multi-stakeholder forum how best to eliminate existing barriers and market concerns regarding recycling.

The Toxics Caucus of the CEN feels that the need to focus on, and promote the recycling of base metals is fundamental. The view of the Toxics Caucus on the enormity of the impact on the environment from the mining and smelting sectors is summarized in Appendix 7. They believe this scale of impact requires that the roles of these two sectors be examined from a broader environmental sustainability perspective. The current rates of materials consumption are considered unsustainable, not so much due to the shortages of materials themselves, but rather due to the extent of environmental costs associated with their extraction and processing. Dealing with this environmental damage will require significant changes in the way in which minerals are used. A less destructive approach would be to maximize the conservation of mineral stocks already circulating in the global economy, thereby reducing both the demand for new materials, and the environmental damage done to produce them. There are many technical opportunities for using minerals more efficiently and they need to be promoted by a transition planning process. Transition planning can be defined as a planning process to shape and guide the implementation of a virtual elimination policy, whose target, completion date and interim performance goals have already been mandated. While transition planning need not be used in all circumstances, for this sector it should allow for an orderly and economically sensitive plan towards secondary materials. Thus, the Toxics Caucus of the CEN recommends that the Standing Committee on Environment and Sustainable Development develop transition planning mechanisms to allow for an orderly transfer of technologies, for retraining workers and for restructuring primary smelters, to secondary smelters, and should examine means to implement a major transformation to secondary materials over a period of 25 years.

9.7 Dioxins and Furans - Recommendation No.7

It is recommended that smelters which have chlorinated plastics or other chlorinated substances in their feeds, test for and report any emissions of dioxins and furans to the Federal-Provincial Task Force on Dioxins and Furans by December 1997, using standardized testing and analytical procedures, and that if found, releases of these substances be appropriately managed as TSMP Track 1 substances.

9.8 Research and Development - Recommendation No.8

It is recommended that industry, governments and other stakeholders should undertake cooperative scientific research programs to characterize[9] smelter releases, validate predictive models, investigate environmental behaviour and effects, and identify and develop pollution prevention opportunities and technologies.

[9] "Characterize" includes chemical, mineralogical, physical, toxicological or thermal characterisation.

9.9 SOR Public Education and Communication - Recommendation No.9

It is recommended that governments, in cooperation wherever possible with industry and other stakeholders, establish ongoing public education and communication programs, such as outreach programs for communities in the vicinity of BMSS facilities, to ensure public awareness of the recommendations and commitments within this Strategic Options Report and to support public accountability and review of the efforts made to respond to these recommendations and to accomplish these commitments.

9.10 Public Review of SOR - Recommendation No.10

It is recommended that a public review process should be initiated by the Ministers of Environment and Health in 2001 to assess the implementation and the effectiveness of the recommendations of this Strategic Options Report. The evaluation should focus on the management of the *CEPA* Substances released by the BMSS to determine if further regulatory or non-regulatory action is needed, taking into account the federal policy on sustainable development.

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APPENDIX 1

Issue Table Participants

on the

Base Metals Smelting Sector

Strategic Options Process

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APPENDIX 1

Issue Table Participants
on the
Strategic Options Process
Base Metals Smelting Sector

ACTIVE MEMBERS	ORGANIZATION
Federal Government	
John Ayres	Environment Canada
Bob Blain	Environment Canada
Ray Capowski	Environment Canada
Mike Clapham	Industry Canada
Brad Cumming	Environment Canada (Ontario Region)
Patrick Finlay (Chair)	Environment Canada
Claude Fortin	Environment Canada
Bill McCutcheon/John Keating	Natural Resources Canada
Lorraine Seed	Health Canada
Jim Skeaff	Natural Resources Canada
Provincial Governments	
Yousry Hamdy	Ontario Ministry of Environment and Energy
Jean Lavergne	Ministère de l'Environnement et de la Faune du Québec
Public Advocacy Groups	
Stéphane Gingras	Toxics Caucus of the Canadian Environmental Network
Robert Higgins	Canadian Lung Association
Burkhard Mausberg	Toxics Caucus of the Canadian Environmental Network
Terry Oke	Trail Lead Program
Primary Smelters	
Thomas Burnett	Inco Limited
Charlie Ferguson	Inco Limited
Wayne Fraser	Hudson Bay Mining & Smelting Co.
Graham Kenyon	Cominco Ltd.
Jacques Moulins	Noranda Metallurgy Inc.
Howard Siebert	Sherritt International Corp.
Leonard Surges	Noranda Mining and Exploration Inc.

Wally Szumylo	Inco (Copper Cliff)
Robert Telewiak	Falconbridge Limited
Hennie Veldhuizen	Noranda Metallurgy Inc.

Secondary Lead Smelters

Roger Laporte	Nova Pb
Sergio Legati	Tonolli

OBSERVERS

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Robert Sensenstein/Paul Walters	Health Canada

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Don Fast	B.C. Ministry of the Environment
Gordon Ford	B.C. Ministry of the Environment
Don Grass	New Brunswick - Dept. Of the Environment
Don Jardine	Prince Edward Island - Environment
Carl Johnson	B.C. Ministry of the Environment
Jerry Lack	Alberta Environmental Protection
Derrick Maddocks	Newfoundland Dept. Of Environment & Labour
Clive Oldreive	Nova Scotia - Department of the Environment
Larry Strachan	Manitoba Environment

SUPPORT STAFF AND CONSULTANTS

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Patricia Holst	Environment Canada
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Julie Malboeuf	Environment Canada
David Niemi	Environment Canada
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Weldon Thoburn	Hatch Associates Ltd.
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APPENDIX 2

Bibliography

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APPENDIX 2 - Bibliography

ARET Secretariat, *Voluntary Commitments to Action on Toxics Through ARET, Environmental Leaders*, (1995).

Canada Gazette Part I, *Canadian Environmental Protection Act - The Second Priority Substances List, 4238*, December 16, (1995).

Canada Gazette Part II, vol.124, No.10, *Regulatory Impact Analysis Statement*, p.1704, (1990).

Canada Gazette Part II, *An Act Respecting the Protection of the Environment and of Human Health*, Chapter 16, 1-88, (1988).

Canada Gazette Part I, *Canadian Environmental Protection Act - Priority Substances List, 543-545*, (February 11, 1989).

Canadian Council of Ministers of the Environment, *CCME 1993-94 Annual Report*.

Canadian Council of Ministers of the Environment, *A Strategy to Fulfil the CCME National Commitment to Pollution Prevention*, A Report Prepared by the CCME Pollution Prevention Task Group, Environmental Protection Committee, Approved by Environmental Protection Committee, (June 27, 1995).

Environment Canada, *Guidance Document on the Options Evaluation Process*, (1994).

Environment Canada, *Guidelines for Conducting Environmental Assessments for Priority Substances under CEPA*, (1992).

Environment Canada, *National Pollutant Release Inventory*, Summary Report, (1994).

Environment Canada and Ontario Ministry of Environment and Energy, *The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem*, (1994).

Environment Canada, *Pollution Prevention - A Federal Strategy for Action*, (1995).

Environment Canada, *Summary Report of the 1993 National Pollutant Release Inventory*, (1995).

Environment Canada, *1994 National Pollutant Release Inventory*.

Fisheries Act, Metal Mining and Liquid Effluents Regulations (MMLERs), (1977).

Government of Canada, *The Minerals and Metals Policy of the Government of Canada - Partnerships for Sustainable Development*, (1996).

Government of Canada and Environment Canada, *Toxic Substances Management Policy*, (1995).

Government of Canada, Environment Canada and Health Canada, Canadian Environmental Protection Act - Priority Substances List Assessment Reports for the following substances: *Arsenic and its Compounds*, (1993).

Government of Canada, Environment Canada and Health Canada, Canadian Environmental Protection Act - Priority Substances List Assessment Reports for the following substances: *Cadmium and its Compounds*, (1994).

Government of Canada, Environment Canada and Health Canada, Canadian Environmental Protection Act - Priority Substances List Assessment Reports for the following substances: *Nickel and its Compounds*, (1994).

Government of Canada, Environment Canada and Health Canada, Canadian Environmental Protection Act - Priority Substances List Assessment Reports for the following substances: *Polychlorinated Dibenzodioxins; Polychlorinated Dibenzofurans*, (1990).

Hatch Associates Ltd., Base Metal Smelting Sector Strategic Options Study, Rev. 1 (March 31, 1997) .

Health Canada, *Health Risk Determination*, (1990).

Health Canada, *Human Health Risk Assessment for Priority Substances*, (1994).

Health Canada, *Guiding Principles for the Risk Management of Toxic Substances*, (1995).

Minister of Supply and Services Canada, *Canadian Environmental Protection Act*, R.S., 1985, c 16 (4th Supp.), as amended (Office Consolidation, 1994).

Organization for Economic Cooperation and Development (OECD), *Risk Reduction Monograph No. 1: Lead* (1993).

Smith, Bucklin and Associates, Inc., *1994 National Recycling Rate Study*, Chicago, (November, 1995).

United Nations Conference on Environment and Development (UNCED), *The Rio Declaration on Environment and Development*, (June 15, 1992), Principle 15.

United States Environmental Protection Agency, *EPA Toxicology Handbook* (1992).

World Commission on Environment and Development, *Our Common Future*, (1987).

APPENDIX 3

Acronyms and Glossary of Terms
used in the SOR

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APPENDIX 3- Acronyms and Glossary of Terms use in the SOR

3.1 ACRONYMS, ABBREVIATIONS AND SYMBOLS

AQUAMIN	The Assessment of the Aquatic Effects of Mining (in Canada)
As	Arsenic
ARET	Accelerated Reduction / Elimination of Toxics Program
BMSS	Base Metals Smelting Sector
CCME	Canadian Council of Ministers of the Environment
Cd	Cadmium
CEN	Canadian Environmental Network
CEPA	*Canadian Environmental Protection Act*
CEPA FPAC	*Canadian Environmental Protection Act* Federal-Provincial Advisory Committee
CLA	Canadian Lung Association
COA	Canada-Ontario Agreement
EPI	Exposure/Potency Index
ENGO	Environmental Non-Governmental Organization
Hg	Mercury
IT	Issue Table
MAC	Mining Association of Canada
MMLERs	Metal Mining Liquid Effluent Regulations
Ni	Nickel
NPRI	National Pollutant Release Inventory
Pb	Lead
PCBs	polychlorinated byphenyls
PCDDs	polychlorinated dibenzo-para-dioxins
PCDFs	polychlorinated dibenzofurans
PSL	Priority Substances List
SLSRRs	Secondary Lead Smelter Release Regulations
SLV 2000	St. Lawrence Vision 2000
SOP	Strategic Options Process
SOR	Strategic Options Report
TSMP	Toxic Substances Management Policy
UNCED	United Nations Conference on Environment and Development

3.2 GLOSSARY OF TERMS

Acid Plant:	a process that converts sulphur dioxide into sulphuric acid. At a base metal smelter sulphur dioxide is produced by the oxidation of sulphide mineral concentrates and other minerals contained in smelter feed materials. The acid plant converter oxidizes sulphur dioxide to sulphur trioxide in the presence of a catalyst. Single or double absorption stages may be used to absorb sulphur trioxide in water.
Baghouse: (Fabric filter)	removes particulate matter from a gas stream by passing the stream through a porous fabric.
Blast Furnace:	a shaft furnace in which metallurgical coke is burned with air and the resulting carbon monoxide reduces lead sinter to the metallic state, producing molten bullion and slag phases.
Converting:	process of removing impurities or metallic compounds from molten metal by blowing air through the liquid matte. The impurities or metallic compounds are changed either to gaseous compounds, which are removed by volatilization, or to liquids, which are removed as slags.
Dry Scrubber	a dry scrubber is any device that separates gas-borne particles from a gas stream by such methods as gravitational deposition, flow-line interception, diffusional deposition, and electrostatic deposition. Most forms of dust collection systems use more than one of these collection mechanisms
Effluent:	a release of an aqueous flow.
Electric Furnace:	a furnace using electricity to supply heat/thermal energy. The chief types of such furnaces are: direct arc, in which the electric current passes through the charge; indirect arc, in which the arc is struck between the electrodes only; induction furnace, in which the metal charge is heated by magnetic susceptibility.
Electrorefining: (Electrolytic Refining)	separates the desired metal from impure metal by electrolysis in a solution normally containing an aqueous sulphate form of the metal and sulphuric acid. Metallic impurities which do not dissolve form a sludge which is removed and treated to recover precious metals. An electric current dissolves the impure metal at the anode and selectively plates high purity metal at the cathode.

Electrostatic Precipitator:	a particle collection device that uses electrostatic forces to move particles out of the flowing gas stream and on to collector plates. The particles are given an electrostatic charge as they pass through a corona that is produced by electrodes maintained at high voltage in the centre of the flow lane. The charged particles are then forced to the collection plates where they are collected.
Electrowinning:	production of high purity metal from a metal-bearing solution. The process takes place in cells containing a number of closely spaced rectangular metal plates acting as anodes and as cathodes. A series of reactions occurs in the electrolysis cells that results in deposition of the desired metal at the cathode and the regeneration of sulphuric acid in the electrolyte at the anode. This differs from electrorefining in that the source metal is already in solution.
Emission:	a release of a gaseous flow.
Flash Converting:	very fast smelting of copper can be accomplished in a converter by feeding the matte and supplying oxygen. The oxygen efficiency is high, no fuel is required, and the offgas is very high in SO_2
Flash Smelting:	combines the operations of roasting and smelting to produce a high grade matte. Dried ore concentrates and finely ground fluxes are injected together with oxygen, preheated air or a mixture of both into a furnace of special design where the temperature is maintained.
Fluid Bed Roasting:	oxidation of finely ground pyritic minerals by means of upward currents of air, blown through a reaction vessel with sufficient force to cause the bed of material to fluidise.
Fugitive Emissions:	these emissions are usually resulting from process leakages and spills of short duration, and are associated with storage, material handling, charging, tapping and other process operations.
Matte	a molten solution of metal sulphides produced during smelting.
Matte Separation:	after controlled cooling of a nickel-copper matte, involves crushing, grinding, magnetic separation and flotation to separate copper and nickel sulphides for future processing.
Mitsubishi Continuous Smelting	injects dried concentrate through a lance into the smelting furnace. Oxygen rich air conveys the concentrate and oxidizes the bath.

Noranda Process Reactor and Converters:	produces copper matte by feeding fuel, flux and coal while oxygen enriched air is blown into the liquid matte. A long settling zone in the reactor allows for the separation of slag and matte. The matte proceeds on to a converter while the slag is cooled, a sulphide rich fraction concentrated and sent for recycle to the reactor.
Particulates:	Particulates are any finely divided solid or liquid particles in the air or in an emission. Particulates include dust, smoke, fumes and mist, etc.
Pierce-Smith converters:	the most common type of converters are refractory lined, cylindrical, steel shells mounted on trunions on either end and rotated about the major axis for charging and pouring. Air or oxygen rich air is blown through the moten matte where iron and sulphur are oxidized.
Primary Smelting:	a process where mine concentrate or calcine is smelted.
Pressure Leach:	in chemical extraction of valuable ore constituents, use of autoclaves to accelerate attack by means of increased temperatures and pressures.
Roasting:	the charge material of metal sulphides (ore concentrates) is heated in air partially eliminating the sulphur as sulphur dioxide in order to facilitate smelting.
Roast-Leach:	roasting of sulphide concentrates followed by acid leaching acid and electrowinning for recovery of metals.
Secondary Smelting:	involves the smelting of scrap materials or the reclaiming/recycling of a metal into a usable form.
Sedimentation:	In wastewater treatment, the settling out of solids by gravity.
Sinter:	an intermediate silicate material with suitable porosity and mechanical properties, produced by the oxidation of mineral concentrates blended with fluxes in the solid phase for removal of sulphide as sulphur dioxide.
Slag:	a molten layer formed on top of a bath of liquid metal or matte when iron and other impurities in the charge oxidize and mix with flux.

Slag cleaning:	slag containing significant amounts of the desired metal is treated in a slag cleaning furnace to extract the desired metal and reduce the amount of magnetite. Usually slag from flash furnaces and converter furnaces requires cleaning. The slags are charged to a slag cleaning furnace (usually an electric furnace) where the metals and metal sulphides are allowed to settle under reducing conditions with the addition of coke or iron sulphide.
Top Blown Rotary Converter Smelting (TBRC):	converter that allows rapid and independent temperature and atmosphere control by the introduction of oxygen, an oxygen-fuel mixture or other gases above the furnace bath which is stirred by the rotation of the vessel.
Wet Scrubbers:	remove particles from the gas stream by capturing the particles in liquid (usually water) droplets and separating the droplets from the gas stream. The droplets act as conveyors of the particulate out of the gas stream.

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APPENDIX 4

Health and Environmental Profiles for *CEPA* Substances

Note: This Appendix was prepared by Environment Canada and Health Canada IT members with input from several other IT members.

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APPENDIX 4 HEALTH AND ENVIRONMENTAL PROFILES FOR *CEPA* SUBSTANCES

Introduction

A number of substances released, produced or used by the Base Metal Smelting Sector have been assessed and declared toxic under paragraphs 11(a) and (c) of the Canadian Environmental Protection Act (*CEPA*). The Priority Substance List (PSL) assessment reports for arsenic, cadmium and nickel and their compounds, and for polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) assessed whether these substances are present in the environment in quantities or concentrations that have an immediate or long-term harmful effect on the environment and that constitute a danger in Canada to human life or health. It was concluded that some forms of these compounds (see Section 3 for list of actual compounds) meet these conditions. Mercury and lead, also released by this sector, were regulated under the *Clean Air Act* and were placed on the List of Toxic Substances when the *Clean Air Act* was incorporated into *CEPA*.

The purpose of Environment Canada in this undertaking is to consider options to reduce the releases and the environmental impacts of substances considered toxic under *CEPA*. Similarly, the goal of Health Canada in this exercise is to minimize health risks by examining measures to reduce human exposure to these substances, in accordance with the recommendations contained in the Priority Substances Assessment Reports and "Guiding Principles for the Risk Management of Toxic Substances" (Health Canada, 1995).

The approach used by Health Canada in the assessment of PSL 1 substances is described in the publication "Human Health Risk Assessment for Priority Substances" (Health Canada, 1994). The conclusions of the health assessments are based on critical review of available toxicological and epidemiological studies and assessment of exposure to these substances in environmental media. Human exposure to environmental substances may occur by inhalation, ingestion and/or dermal absorption from air, water, soil and food. To the extent possible, information on concentrations of the Priority Substances acquired in national surveys of ambient air, drinking water, soil and food is used as the basis for the assessment of exposure of the general population. Due to the lack of identified data on the speciation of metals in various environmental media, it was not possible to estimate the exposure of the general population to individual compounds. Standardized reference values for body weights, the volume of air breathed, and quantities of food, water and soil ingested, form an integral part of the estimation of exposure from these sources. Human exposure is estimated for several defined stages of life due to the fact that exposure levels may change substantively over the course of an individual's lifetime. Where possible and appropriate, exposure estimates for "high exposure" subgroups in the general population are considered.

With respect to the assessment of adverse health effects associated with exposure to a particular substance, Health Canada adopts one of two approaches, depending upon whether the critical effect is considered to have or not to have a threshold. For many types of toxic effects (i.e., organ-specific, neurological/behavioral, immunological, reproductive or developmental), the current scientific understanding is that there is a dose or concentration below which effects will not occur (i.e., a threshold). However, for genotoxic carcinogenesis and for mutagenesis it is generally assumed that there is some probability of harm at any level of exposure (i.e., that no threshold exists). For substances for which the critical effect is believed to have no threshold, it is assumed there is some probability of harm to human health at any level of exposure, and consequently it is not appropriate to calculate a dose below which adverse effects are not expected to occur. Therefore, it is the policy of Health Canada that human exposure to substances that have been assessed as carcinogenic to humans, or probably carcinogenic to humans, should be reduced to the greatest extent possible.

In 1992, Environment Canada issued draft "Guidelines for Conducting Environmental Assessments for Priority Substances Under *CEPA*". The purpose of this document is to describe what information should be included in a PSL environmental assessment, how that information is to be used, and, given the diversity of substances on the Priority Substances List, emphasize the need for scientific judgement to ensure that assessors have the capability and flexibility necessary to conduct scientifically-defensible environmental assessments for each of the listed substances. In general, Environment Canada addresses three major components when conducting an assessment: (i) proving entry to the environment; (ii) proving exposure to biota in the environment; and (iii) proving effects to the environment. If a substance enters the Canadian environment, and biota are exposed to levels high enough to cause harmful effects, the conclusion is that the substance is *CEPA* toxic. Conversely, if a substance does not enter the Canadian environment or biota in Canada are not exposed to the substance at levels high enough to cause harmful effects, then a substance is not declared toxic.

Both Health Canada and Environment Canada recognize that scientific uncertainty is a factor in the risk assessment process. Like traditional science, risk assessment examining human and environmental risk invariably identifies new data needs and generates recommendations for additional research. However, unlike traditional scientific exploration, risk managers must inevitably make decisions in the face of scientific uncertainty. In addition, it is recognized that while zero risk is always an ideal, it is not always an attainable ideal. Zero risk is unattainable for contaminants that, at least partly, are naturally occurring in the environment (Health Canada, 1990). It is also recognized that the incremental risks associated with exposure to low levels of a toxic substance may be small relative to other risks in society. Therefore, in consideration of these factors it may be both impractical and unnecessary to reduce exposure to zero.

Nonetheless, as stated in the "precautionary principle" (Principle 15 of the Rio Declaration on Environment and Development), where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. Health Canada's position is that where significant adverse health effects are known to be associated with exposure to a toxic substance, the lack of full scientific data should not prevent the consideration of control measures (Health Canada, 1995).

Assessment of Health and Environmental Effects

Arsenic and its Compounds

It has been consistently demonstrated in numerous occupational studies that exposure by inhalation of inorganic arsenic compounds causes cancer of the respiratory tract. Ingestion of arsenic in drinking water or medicines has also been linked with skin cancer and cancers of various internal organs including the bladder, kidney, lung and liver. Health Canada has concluded on the basis of available data that the group of inorganic arsenic compounds as a whole are carcinogenic to humans, and therefore toxic under Section 11(c) of *CEPA*.

Concentrations of dissolved and soluble forms of inorganic arsenic in environmental media in the vicinity of anthropogenic sources are high enough to cause adverse effects in a variety of aquatic and terrestrial organisms. Therefore, Environment Canada has concluded that dissolved and soluble forms of inorganic arsenic are toxic under Section 11(a) of *CEPA*.

Cadmium and its Compounds

The determination of toxicity was based principally on the observation of an increased incidence of cancer in experimental animals exposed to inorganic cadmium compounds by inhalation. In addition, cadmium has been associated with the development of kidney disease in humans in both occupational and non-occupational situations, and in experimental animals. There is evidence that mild effects on the kidney are associated with levels of cadmium at or near those to which a portion of the Canadian general population is exposed. There is also evidence that some inorganic cadmium compounds are genotoxic in mammalian cells *in vivo* and *in vitro*. On the basis of available data, inorganic cadmium compounds have been classified as "probably carcinogenic to humans" by Health Canada, and are therefore classified as toxic under Section 11(c) of *CEPA*.

Cadmium levels in some Canadian water bodies in the vicinity of known anthropogenic sources have been found to exceed the estimated effects threshold for the most sensitive environmental species. Similarly, cadmium levels in kidney tissue of some Canadian mammalian wildlife and domestic species have exceeded the estimated effects threshold

for renal dysfunction determined in laboratory animals. Therefore, Environment Canada has concluded that dissolved and soluble forms of inorganic cadmium are toxic in accordance with Section 11(a) of *CEPA*.

Dioxins (Polychlorinated Dibenzo-p-Dioxins - PCDDs) and Furans (Polychlorinated Dibenzofurans - PCDFs)

Chlorinated dioxins and furans are highly persistent, fat-soluble compounds which have been found in all compartments of the ecosystem including air, water, soil, sediments, animals and foods, and have a high potential for accumulating in biological tissues. All animals and humans in Canada are exposed to these substances. The compound 2,3,7,8-TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin), and to a lesser extent, the other chlorinated dioxins and furans substituted in the 2, 3, 7 and 8 positions are extremely toxic to mammals, with a wide variation in sensitivity among species. Studies of human populations indicate that exposure to several milligrams of mixtures of chlorinated dioxins and furans can lead to a variety of effects on skin, eyes and sensory and behavioral processes. Virtually all of this intake comes from food. Some chlorinated dioxins and furans are very persistent, and continued release of these chemicals into the environment could unnecessarily prolong exposures, with a resultant increase in the risk to the environment and human health. In the PSL assessment, Health Canada concluded that there is no adequate demonstration that human populations exposed to chlorinated dioxins and furans have suffered excess cancer. However, based on the results of studies in animals, it was assumed that chlorinated dioxins and furans are non-genotoxic carcinogens and reproductive toxicants with a threshold, and therefore a tolerable daily intake for human exposure was derived. It was estimated that some fish-eating populations could have intakes that approach or exceed this guideline for intake. Based on these considerations, the Ministers of Environment and Health have concluded that PCDD/PCDF may enter into the environment in quantities which have immediate and long-term harmful effects on the environment, and which constitute a danger in Canada to human health. These substances are therefore considered toxic as defined under Sections 11(a) and (c) of *CEPA*.

Lead

Studies have indicated that chronic exposure to even small amounts of lead can be harmful. Lead may enter the body through ingestion or inhalation. Certain organic species of lead may also enter the body through dermal contact. Once lead is absorbed, it is distributed to the soft tissues and the skeleton. Lead in the skeleton represents long-term accumulation and its half-life is several decades. Recent research has shown that adverse health effects, particularly neurological, may occur at blood levels previously thought not to result in adverse effects. Evidence is growing that effects may occur at blood lead levels of 10 μg/dl or lower. Chronic exposure to lead is associated with blood and kidney problems, as well as neurological disorders. Childhood neurological disorders such as hyperactivity, learning disabilities and possibly lower IQ scores have been linked

to lead. Studies also show that pregnant women with high levels of lead in their blood have a greater risk of miscarriages, stillbirths and premature deliveries. Possible environmental impacts of exposure to lead include mortality and reduced growth in algae, reduced growth of micro-organisms, reduced survival, growth and reproduction of aquatic invertebrates, malformations and reduced survival of fish, mortality and reduced reproduction in amphibia, and reduced survival, growth and/or reproduction in terrestrial plants and invertebrates. Lead was regulated under the *Clean Air Act* and was placed on the List of Toxic Substances when the *Clean Air Act* was incorporated into *CEPA*.

Mercury

It has been shown that long-term exposure to either organic or inorganic mercury can permanently damage the brain, kidneys, and developing foetuses. Mercury may enter the body through ingestion or inhalation. Metallic mercury, inorganic mercury compounds and alkyl mercurials are known to cross the skin barrier. Mercury is of particular concern because of its tendency to methylate, and because methyl mercury bioaccummulates and biomagnifies in the food web, which may contribute to increased exposure. Mercury was regulated under the *Clean Air Act* and was placed on the List of Toxic Substances when the *Clean Air Act* was incorporated into *CEPA*.

Nickel and its Compounds

Based on the results of epidemiological studies of occupationally-exposed workers, there is a clear association between inhalation of each of the groups, oxidic, sulphidic and soluble nickel compounds and the development of respiratory and nasal cancer. Exposure to some nickel compounds has also been associated with non-neoplastic effects (including contact dermatitis in humans and experimental animals). Genotoxic effects have also been observed in studies in both humans and animals. Inhalation of some nickel compounds has also been observed to induce cancer in experimental animals. Using a "weight-of-evidence" approach, Health Canada has concluded that each of the groups, oxidic, sulphidic and soluble nickel compounds are carcinogenic to humans, and therefore toxic under Section 11(c) of *CEPA*.

Comparison of reported effect levels to environmental concentrations indicates that dissolved and soluble forms of inorganic nickel likely cause harmful effects in sensitive pelagic organisms and terrestrial plants in the vicinity of major anthropogenic and natural sources. Therefore, based on the available information, Environment Canada has concluded that dissolved and soluble forms of inorganic nickel are toxic in accordance with Section 11(a) of *CEPA*.

Considerations Regarding Human Exposure

Arsenic, cadmium, lead, mercury and nickel are present in various environmental media across Canada. Canadians are exposed to these substances in food, drinking water, soil and ambient air, with food generally being the largest source of intake. People residing in

the vicinity of point sources may be exposed to higher levels of these substances in all media, and consequently the risk of adverse health effects may be further increased. Nickel and cadmium levels may be elevated in the vicinity of smelting operations. The highest concentrations of inorganic arsenic compounds occur near active and abandoned gold- and base-metal mining and ore processing facilities, and areas affected by the use of arsenical pesticides. It should be also noted that exposure to these substances may be elevated in populations residing in the vicinity of geological sources. Canadian and U.S. studies note that mercury is elevated in air, water, soil and grain crops as a result of industrial and natural sources, and accumulates in certain fish in lakes and oceans, any of which may contribute to increased exposure.

Inorganic arsenic compounds, inorganic cadmium compounds and each of the groups, oxidic, sulphidic and soluble nickel compounds have been classified as substances for which the critical health effect (cancer) is believed not to have a threshold, that is there is some probability of harm at any level of exposure. Therefore, effort should be directed toward reduction of exposure of the Canadian population to the extent practicable. An Exposure/Potency Index (EPI), a measure of risk in which exposure to a substance is compared to its potential to cause cancer, was used in the health assessments to determine the ranking of the toxic substances. Carcinogens with a high EPI are to be given priority in examining measures to control exposure. The EPIs are such that the priority for further action is classified as moderate-to-high for each of the groups, oxidic, sulphidic and soluble nickel compounds and inorganic arsenic compounds , and high for inorganic cadmium compounds. In addition, in view of the fact that mercury and lead have been shown to cause severe non-neoplastic (non-cancerous) health effects and that both have the potential to persist in the body, efforts should also be directed toward minimizing exposure to these substances. Furthermore, with respect to lead, the Canada Gazette (*Regulatory Impact Analysis Statement of the Gasoline Regulations, SOR/90-247*, Part II, Vol. 124, No. 10, May 1990) states, "In order to seek stronger safeguards for the Canadian population and minimize the risk against known and potential harmful effects of lead exposure, the Government of Canada has adopted the policy of reducing blood lead concentration to the lowest possible level...". The latter statement is in accordance with the recommendation of the Royal Society of Canada Commission on Lead in the Environment (1986). There is evidence that the actions taken as a whole in Canada have had a significant health benefit; average blood lead concentrations in Canadian children have shown a steady decline, from about 19 μg/dl in 1972, to 12 μg/dl in 1984, and to 6 μg/dl in 1988 (OECD, 1993).

APPENDIX 5

Overview of the Base Metals Smelting Sector

Note: Appendix 5 was written by industry members of the IT, with input from other IT members.

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APPENDIX 5 OVERVIEW OF THE BASE METALS SMELTING SECTOR

Introduction

Canada is a leading producer and exporter of copper, zinc, lead and nickel. Metallurgical complexes are located in British Columbia, Alberta, Manitoba (2), Ontario (5), Quebec (5) and New Brunswick. Mines that currently produce concentrates are located in every province and territory except Alberta, Saskatchewan, Prince Edward Island and Nova Scotia. Mines and smelters are interdependent. Mine production of copper, lead, nickel and zinc totaled 2.23 million tonnes in 1995, amounting to 13.7% of western world or 10.8% of total world production. The value of mineral production in 1995 was $17.4 billion, of which metals accounted for $12 billion. When the value added by primary manufacturing is included, the metals sector accounted for $23 billion or 4.25% of GNP. Canada is a net exporter of concentrates. Smelters are increasingly reliant on imports of concentrates and other feed materials. On the other hand, some concentrates are exported for technical, logistical, marketing or other reasons. Canadian refined production of the same four metals in 1995 was 1.69 million tonnes, amounting to 8.4% of western world or 6.7% of total world production.

With large mineral reserves and a small population and industrial base, Canada consumes only a small portion of domestic metal production. Domestic consumption in 1995 was 437 thousand tonnes, amounting to 2% of western world, or 1.7% of total world consumption. As a result, Canada is the world's largest exporter of minerals and metals. Canadian refined exports of these four metals accounted for 25% of western world exports during 1995.

Uses of Metals

Uses of copper, lead, nickel and zinc are many and varied. Applications exploit properties of a particular metal or alloy which are unique to that metal or offer an advantage over competitive materials when both price and performance are considered. Metals and alloys produced by the sector compete with one another and with a wide variety of other materials, including plastics, ceramics and other metals.

Approximately two-thirds of copper consumption worldwide is for wire, cables and other electrical conductors. Copper is the most efficient metal for carrying electrical signals and power, on a volumetric basis, except for silver.

The dominant end use for lead is in batteries. Lead-acid batteries are universally used in automotive applications as well as for storage of power generated by electrical utilities during periods of reduced demand. Lead offers low cost and high energy density in such applications, which account for approximately two-thirds of lead consumption worldwide and well over 90% of North American demand.

Nickel's outstanding characteristic is its exceptional corrosion resistance. Addition of nickel enhances steel's ability to meet performance standards in harsh environments such as flue gas desulphurization or other applications. Nickel also plays a vital part in alloys used for turbines in aerospace and other high temperature applications, while stainless steels are used in medical and dental instruments, cookware and numerous other applications that require corrosion resistance.

Zinc is used to impart corrosion resistance to steel, although the mechanism is entirely different than for nickel. A thin coating of zinc provides steel with galvanic protection as a result of the differing electrochemical properties of zinc and steel, even if the coating itself is breached. Without such protection, increased corrosion rates would require world steel production of about 750 million tonnes to increase substantially to avoid premature failure of steel-reinforced concrete structures and automobiles, increasing automobile weights and fuel consumption. Zinc is also used in sacrificial anodes that protect steel pipelines, storage tanks and other critical structures against corrosion failures.

Impurity elements that must be removed to produce copper, lead, nickel and zinc of commercial quality also have properties that are well-suited to particular applications. For example, small quantities of arsenic modify the electronic properties of semiconductor materials. Mercury or mercury compounds are used in scientific reference electrodes, dental amalgams and high density batteries used in hearing aid applications. Cadmium is used in rechargeable batteries and as a stabilizer for plastics.

Process Technologies

Process technologies employed by Canadian smelters and refineries have been designed and developed to ensure acceptable quality of refined metals by rejecting and stabilizing impurities in smelter slag or controlling or recovering impurity elements in smelter or refinery byproducts. Unlike the ores which occur in tropical and arid regions, removal of sulphur and associated iron is a major consideration in the design and operation of metallurgical facilities processing Canadian ores and concentrates. Recent advances in mineral processing have enabled a number of Canadian mills to improve selectivity and to reject a greater fraction of waste sulphide minerals to mill tailings. These innovations have reduced inputs of sulphur, iron and associated impurities to certain Canadian metallurgical facilities, but have not eliminated the need to remove those impurities by chemical processing of sulphide concentrates.

In general, metallurgical processes for Canadian base metal sulphide concentrates must include several steps, although more than one step may be performed within a single reactor vessel or more than one reactor may be used to complete a single step. The first step is the complete or partial oxidation of sulphide sulphur either to sulphur dioxide or to sulphate. The second step is the removal of iron in the form of a basic iron

silicate slag and may or may not be accompanied by the further oxidation of sulphide sulphur to sulphur dioxide. The third step is the reduction of valuable metals to the metallic state. It should be noted that removal of iron in the form of a basic iron silicate slag may take place either in the second or third step. The fourth step is the removal of impurities to produce refined metal and alloys that meet commercial specifications for product quality. The final step is the casting of refined metal and may also involve addition of other metals to produce an alloy. Refinery byproducts may be further processed on site or by another metallurgical facility, as appropriate.

Most economic sulphide minerals are at best sparingly soluble in concentrated sulphuric acid, and therefore direct leaching of concentrates under atmospheric pressure as practiced with oxide ore types found elsewhere would not maximize recovery of metal values. The harsh Canadian climate degrades the performance and process economics for conventional hydrometallurgical processes or newer biological oxidation processes conducted at ambient temperature and atmospheric pressure. Canadian smelters or refineries must generally use either high temperature pyrometallurgical processes or hydrometallurgical processes conducted at elevated temperature and oxygen pressures to achieve acceptable oxidation rates. High volumes of off-gases from the oxidation step must be cleaned to remove moisture and particulate matter prior to recovery of sulphur dioxide as sulphuric acid or liquid sulphur dioxide.

Reduction of the valuable metal to the metallic state is most often achieved by employing coke or another carbon source both as a reductant and as a fuel to achieve the required temperature. Alternately, a furnace may be fired with natural gas or may employ graphite electrodes in the case of an electric arc furnace. High volumes of off-gases from the oxidation step must be cleaned to remove particulate matter. Sulphur dioxide control may not be required where the feed was previously oxidized to an oxide or silicate, but may be necessary where a substantial fraction of sulphide or sulphate remains in the feed and is converted to an oxide within the reactor.

Refining may involve either pyrometallurgical or hydrometallurgical processing, or both. For example, copper anodes are generally refined by an electrorefining process to produce high purity copper cathodes, while lead bullion may be refined by a pyrometallurgical or electrolytic process, with the choice being predicated largely on the basis of electrical power costs. By contrast, zinc is universally produced by purification and electrowinning from a zinc sulphate leach solution.

Recycling

Metals are elements and can be neither created nor destroyed. Performance characteristics of secondary metals, produced from scrap rather than from mineral concentrates, are indistinguishable from those of primary metals. As a result, metal recycling is the most mature of the recycling sectors. Lead has the largest and most

developed recycling component, resulting primarily from the relatively short product life and relative ease of source segregation, collection and recycling for lead-acid batteries. Copper and nickel are also extensively recycled. Competing technologies for stripping zinc from scrap steel and for recovery of zinc from electric arc furnace dusts from steelmaking are under development in North America and in place in Europe.

The significance of secondary smelters is indicated in part by production statistics, although production statistics are not indicative of recycling rates. For the year 1995, total North American lead production was 1,586,000 tonnes. Secondary smelters accounted for 66% of the total while primary smelters accounted for 34% of the total. Logistical factors play a decisive role in site selection for both primary and secondary smelters. Secondary smelters are typically sited near sources of scrap and manufacturing facilities in order to minimize transportation costs, while primary smelters are sited near domestic sources of mine concentrate or a deepwater port to permit receipt of concentrates from offshore. Canadian consumption of metals is low relative to domestic production, but proximity to scrap supplies and customers in the United States as well as Canada has sustained secondary lead smelters in British Columbia, Manitoba, Ontario and Quebec and also provides feed materials to primary lead smelters in British Columbia and New Brunswick.

Production statistics do not reflect the source of smelter feed materials but only the type of facility. Both Canadian primary lead smelters obtain a significant and growing quantity of feed materials from secondary sources. Logistical considerations and production costs have a strong influence on metal marketing and sourcing of secondary materials, since freight costs are high relative to the value of the product and feed material. These factors are especially important for lead, which has the lowest unit price of the four major commodities.

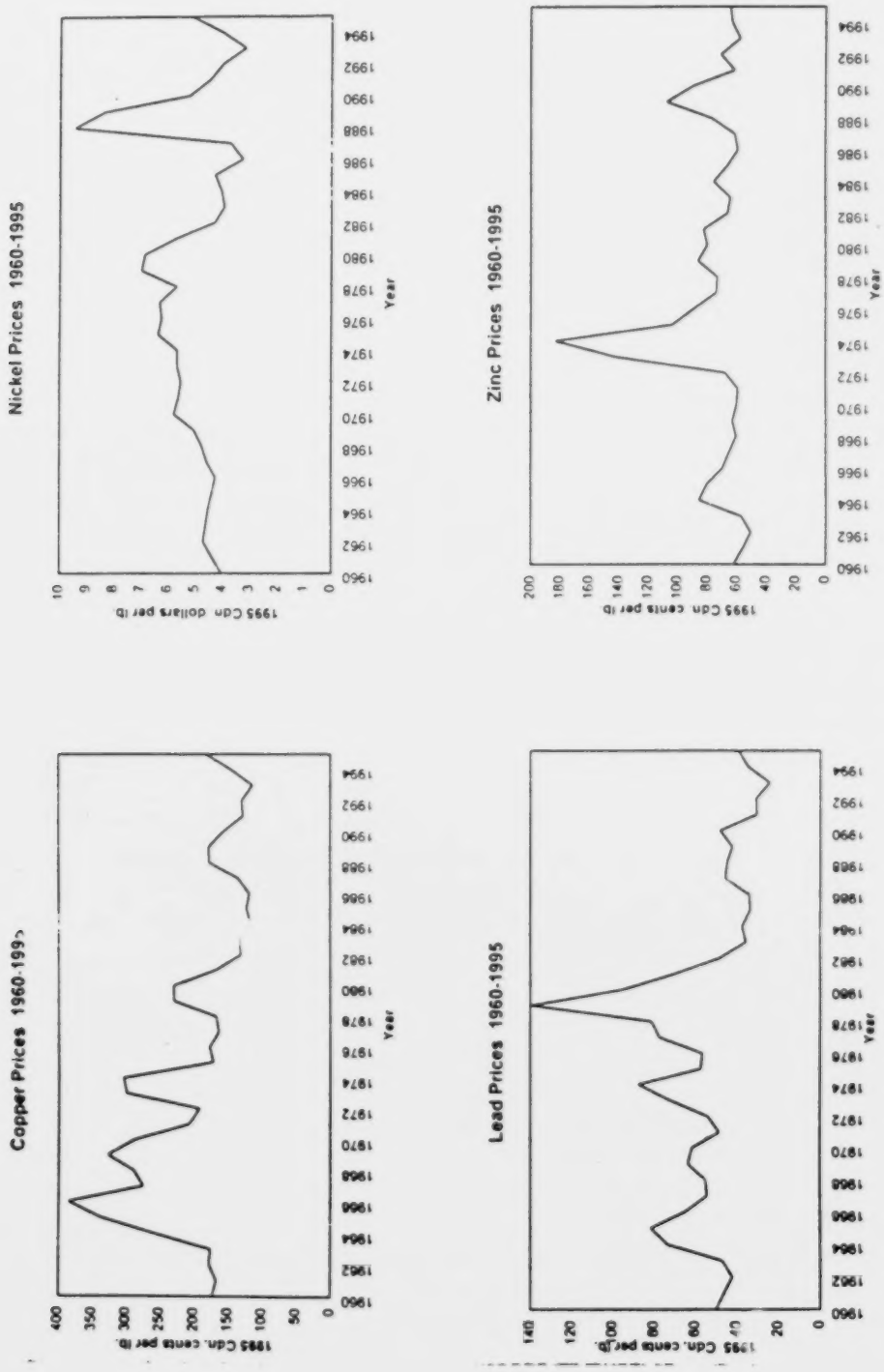
Production statistics also do not reflect growth in the total quantity of lead in service within North America, nor do they take account of net exports of lead metal and lead-acid batteries. When all of these factors are considered, the national lead battery recycling rate for the United States increased from 88.6% for 1987 to 98.2% for 1994. This application also represents the dominant end use in Canada. Earlier studies for Environment Canada suggest that recycling rates in Canada are similar to the United States.

Recycling rates for copper, nickel and zinc are more difficult to establish for a variety of reasons. Applications are more diverse, and product life for major applications of those metals is considerably longer than the useful service life of a lead-acid battery. Exports of metals beyond North America account for a larger proportion of Canadian production, and net imports in manufactured products cannot be quantified with confidence. The higher value of these metals as compared with lead provides a strong economic incentive for recycling and for the development and adoption of new technologies. New technologies, heightened environmental awareness, improved

waste management practices and government policies have all contributed to increased recycling rates for these metals, and this trend is likely to accelerate as manufacturers increasingly design products for recycling and improved life cycle management practices continue to increase the total amount of each metal in service and the availability of scrap as products reach the end of their life.

Copper, nickel, lead and zinc prices are shown in Figure A5.1.

Figure A5.1 Copper. Nickel, Lead, Zinc Prices from 1960-1995



APPENDIX 6

Facility Profiles

The Microsoft Excel computer program was used to manage the data for this report. The data from the individual smelters and refineries was placed in individual tables which are found in this Appendix. If no data was provided for a particular metal parameter in a given year, a blank space appears in the table. If 0.0 (or 0.00 for Hg) appears in a cell in any of the tables in this Appendix, it indicates that the reported value was sufficiently small that it appeared as zero when the figure was rounded off.

Summary Tables 5.1 to 5.6 in Chapter 5 have been generated using Excel from the individual tables in this Appendix . If a cell in the originating data in this Appendix is blank (because there was no data), the corresponding cell in the summary table , by default, will report it as 0.0 (or 0.00 for Hg).

Note: **This appendix was prepared by industry members of the IT with input from Hatch Associates Ltd., Environment Canada and several IT members.**

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6.1 COMINCO LTD., TRAIL OPERATIONS TRAIL, BRITISH COLUMBIA

Profile

Cominco Ltd. operates an integrated primary lead-zinc smelter and refinery, and associated acid and fertilizer plants at Trail, British Columbia. A smelter has existed at this site for 100 years and has evolved into one of the largest integrated lead-zinc smelters in the world. The Trail Operations processes zinc and lead concentrates produced at the company's own mines in B.C. and Alaska, and custom concentrates purchased world-wide. Processed battery scrap materials and other lead recycles are also part of the feedstock. In addition to the primary zinc and lead products, the Operations produce many co-products including silver, gold, bismuth, cadmium, indium, germanium, copper sulphate, copper arsenate, ferrous slag granules, calomel, sodium antimonate, sulphuric acid, liquid sulphur dioxide, elemental sulphur and ammonium sulphate fertilizers. The ability to efficiently recover these minor elements and market them profitably is key to the economic viability of the Trail Operations. A major modernization program was begun in the late 70's and will be completed in 1997 with the startup of a new lead smelter using state-of-the-art Kivcet oxygen flash smelting technology.

Table A6.1.1 Production Summary (tonnes)

Products	1988	1993	1995	2000 (Projected)
Zinc	283,451	219,272	263,570	290,000
Lead	120,081	87,810	93,848	120,000
Silver (ozs.)	10,706,689	5,308,444	6,387,435	7,920,000
Cadmium	522	708	1,061	1,400
Sulphuric acid	404,932	263,680	312,374	325,927
Liquid Sulphur dioxide	55,645	60,667	58,524	65,000
Ammonium Sulphate Fertilizer	138,713	114,789	238,273	281,308
Ammonium Phosphate Fertilizer	99,505	65,786	0	0

Process description

The zinc, lead and fertilizer operations at Trail are completely integrated and co-dependent. Figures A6.1.1 and A6.1.2 show the process flow for the production of lead and zinc respectively.

The principal feedstocks for the zinc production processes are Cominco's Sullivan and Red Dog mine concentrates. Part of the zinc concentrates is roasted and then leached. The other part is leached under pressure with oxygen and sulphuric acid.

During roasting, about one-half of the roaster concentrate (calcine) leaves the roasters via the bed overflow and the rest is carried by the offgas. The offgas entrained calcine is collected in boilers, cyclones, electrostatic precipitators and scrubbers. The gas then passes through mist treaters, a mercury removal process, an SO_2 recovery unit, and final ammonia scrubber followed by a Brinks smoke eliminator before release to atmosphere. The SO_2 recovery processes produce liquid SO_2, sulphuric acid and ammonium sulphate. Liquid SO_2 and a large portion of sulphuric acid are sold. Ammonium sulphate and sulphuric acid are used in the production of fertilizers.

Roaster calcine is leached in sulphuric acid to produce a zinc sulphate solution and a residue. The residue is filtered, washed and processed in the lead smelter. In the pressure leach process, elemental sulphur, zinc sulphate solution and a residue are produced. The elemental sulphur is sold. The residue is filtered, washed and processed in the lead smelter.

The zinc oxide fume produced from the smelter slag fuming process, is leached in sulphuric acid to produce a zinc sulphate solution and a residue. The residue is filtered, washed and recycled back to the smelter. A solvent extraction process integrated in the zinc oxide leaching circuit is used for the production of indium and germanium products.

Zinc sulphate solutions produced from all three leaching processes described above, are blended into one stream and purified. Pure cadmium is produced and sold.

An electrowinning process removes zinc from the purified solution and deposits it on aluminum cathodes. The pure zinc is stripped, melted, alloyed and cast into various shapes for market.

The lead process through until 1997 has been the traditional sintering, blast furnace technology. Lead concentrates from the Sullivan Mine, and other custom concentrates and recycles are sintered on down-draft machines. Sulphur dioxide gas, being too dilute for acid plant use, is treated through an electrostatic precipitator and an ammonia scrubber to remove most of the SO_2. The scrubber solution is used in the production of ammonium sulphate fertilizer.

The sinter is processed through blast furnaces to produce lead bullion and zinc-rich slag. The furnace gases are cooled and filtered through a large baghouse unit, and the dust recycled.

The zinc-rich slag is batch charged to two slag fuming furnaces where zinc oxide is fumed off using air and coal. The fume carrying gas is filtered through a baghouse, and the fume is slurried, dehalogenated and pumped to the Zinc Operations for the recovery of zinc. Barren slag is granulated and sold to cement producers.

The lead bullion from the blast furnaces is charged to the continuous drossing furnace where it is cooled to precipitate a copper matte. The bullion is then softened by oxygen addition to remove arsenic and antimony before being cast into anodes for subsequent electrorefining. Copper matte is used in the production of copper sulphate and copper arsenate.

The Betts electrolytic process is used for refining lead. Lead transfers from the anode and deposits on the cathode. A black slime retained by the anode contains lead, silver, gold, bismuth, arsenic and antimony. Refined lead is cast into ingots for sale. The slime is smelted to remove arsenic and antimony which is recovered in the ventilation baghouse. Gas from this Baghouse is scrubbed to remove gaseous arsenic and fluoride before venting to atmosphere. Part of the arsenic-antimony dust is leached to produce sodium antimonate and copper arsenate and the other part is smelted to produce arsenical and antimonial lead alloys. The bullion is further processed to remove bismuth and lead and then electrorefined to produce silver and gold.

The new lead smelter, starting up in 1997, eliminates several emission sources from the old smelter. Feed concentrates and fluxes are oxygen flash-smelted in a Kivcet furnace. The off-gas has a high concentration of SO_2, and exits via a waste heat boiler and electro-static precipitator to the sulphur gas treatment and acid plants in the zinc operations. The Kivcet unit includes an electric holding furnace. Bullion is tapped to the adjacent continuous drossing operation and slag is intermittently tapped and sent to a new slag fuming furnace. The fume is collected, via a waste heat boiler, in a baghouse for recycle to the zinc operations. The barren slag is granulated in a closed cycle water system, and retrieved for sale to cement plants.

Releases

Point sources of releases to air and water from the refinery are shown on Figures A6.1.1 and A6.1.2. Selected release data for the period 1988 to 1995 are presented in Table A6.1.2 and Figure A6.1.3 and projected levels for the year 2000 are included. Releases of *CEPA* substances decreased by over 56% from 1988 to 1995 and further release reductions are projected.

Figure A6.1.1 Cominco Lead Plant Process Flow Sheet

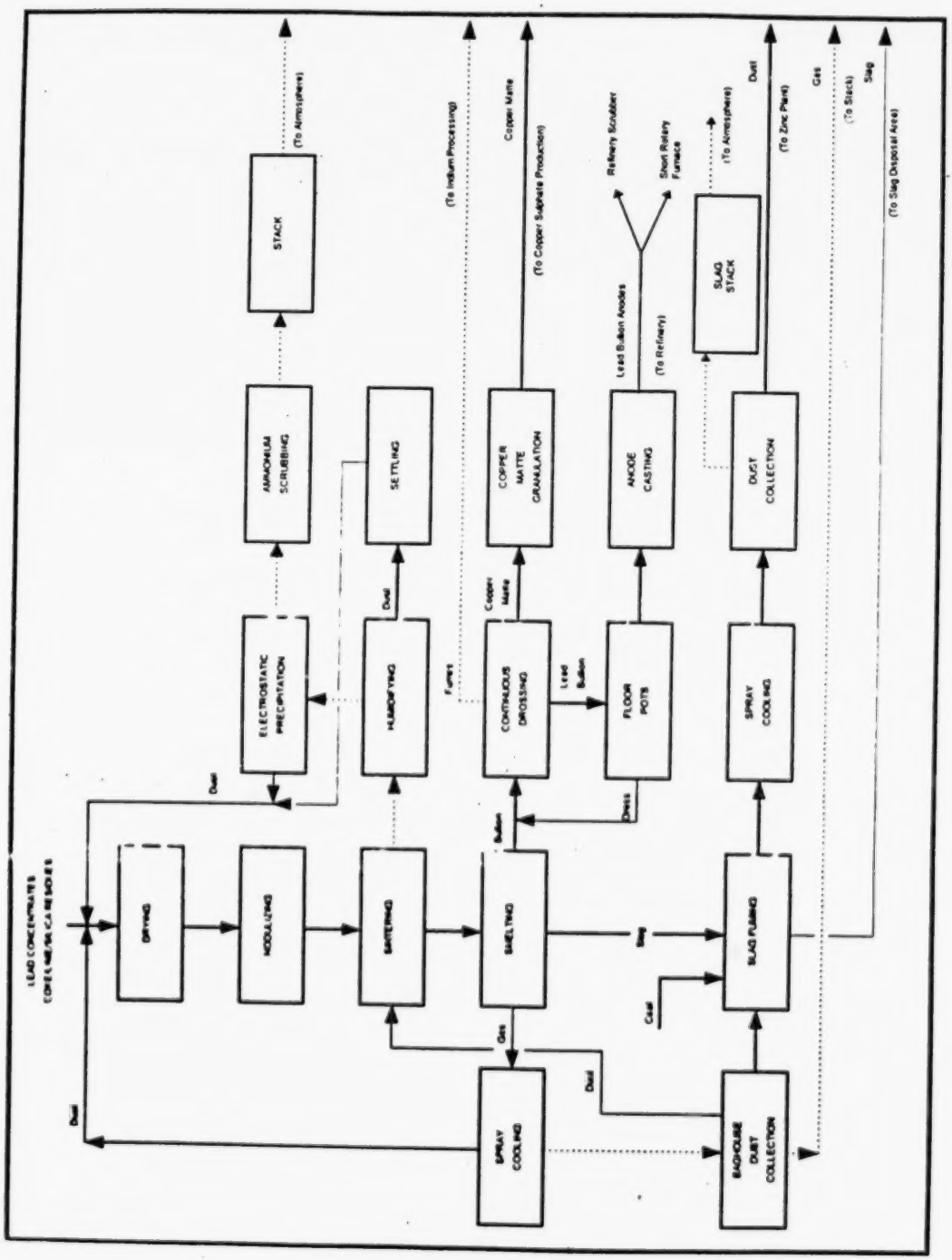


Figure A6.1.2 Cominco Zinc Plant Process Flow Sheet

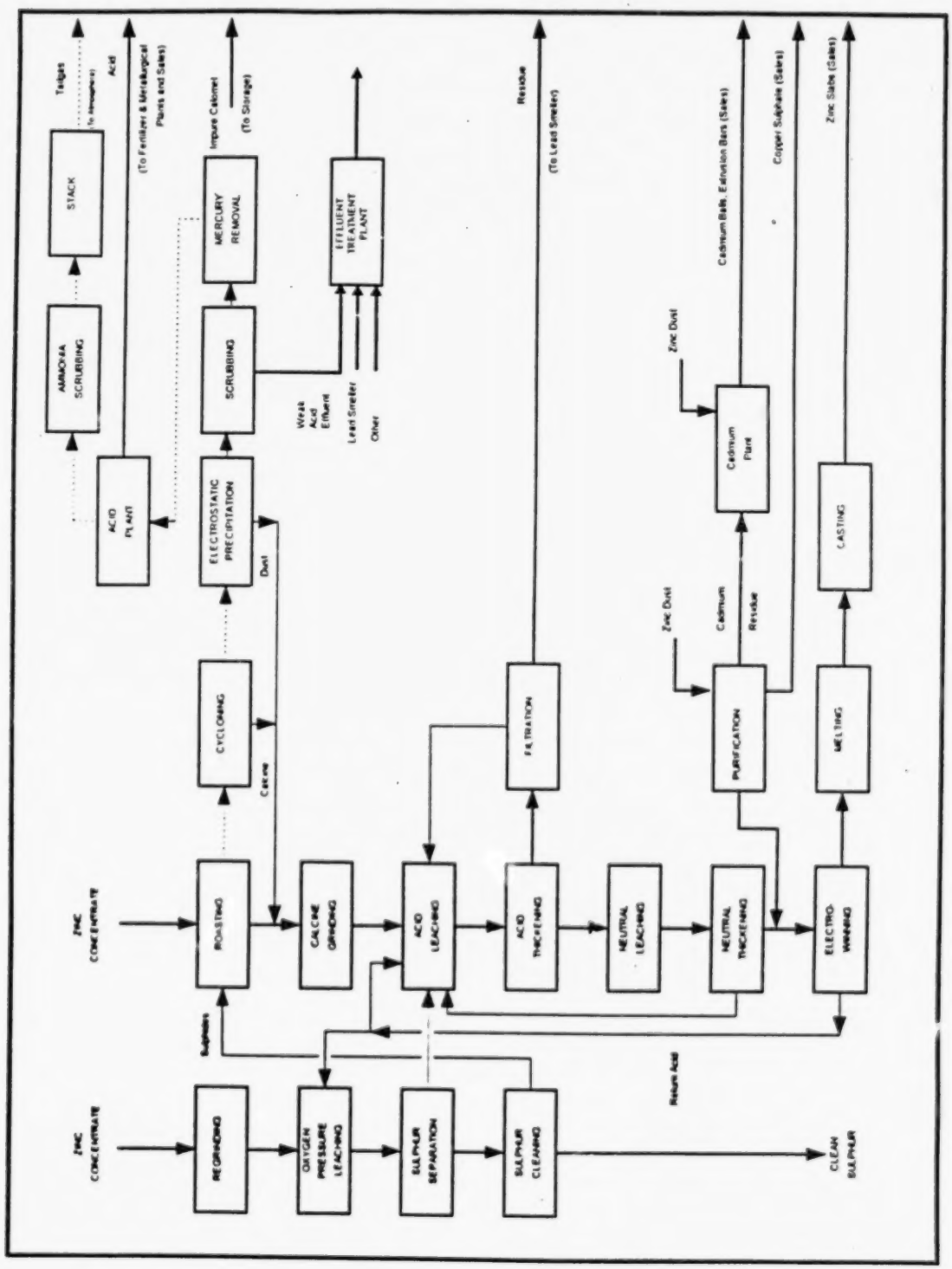
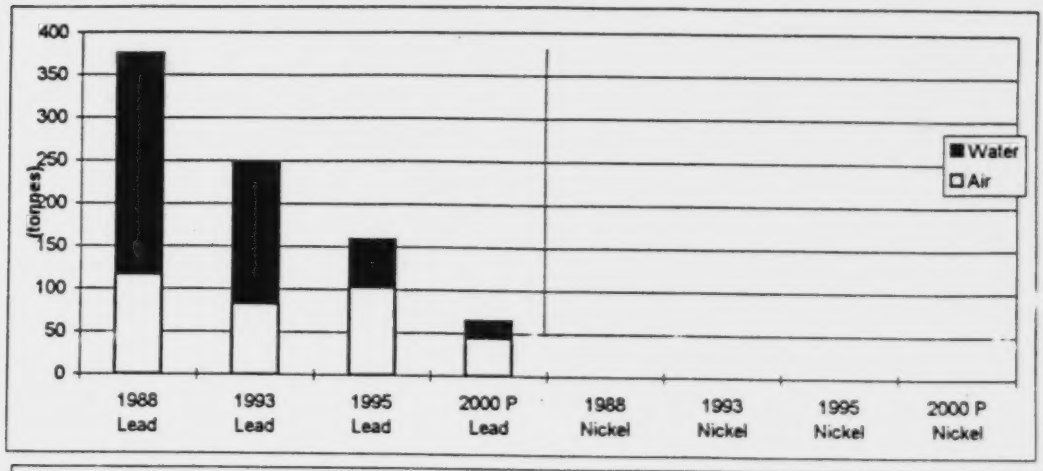
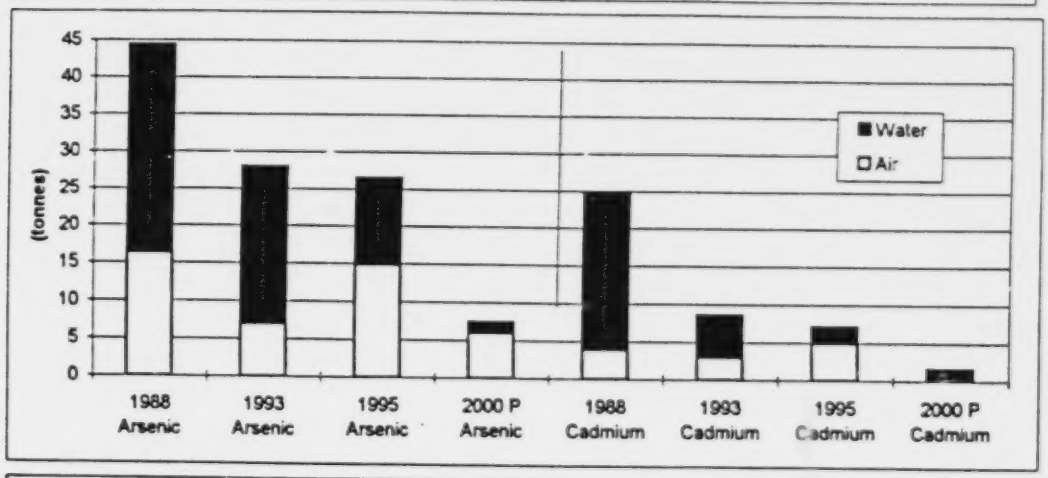


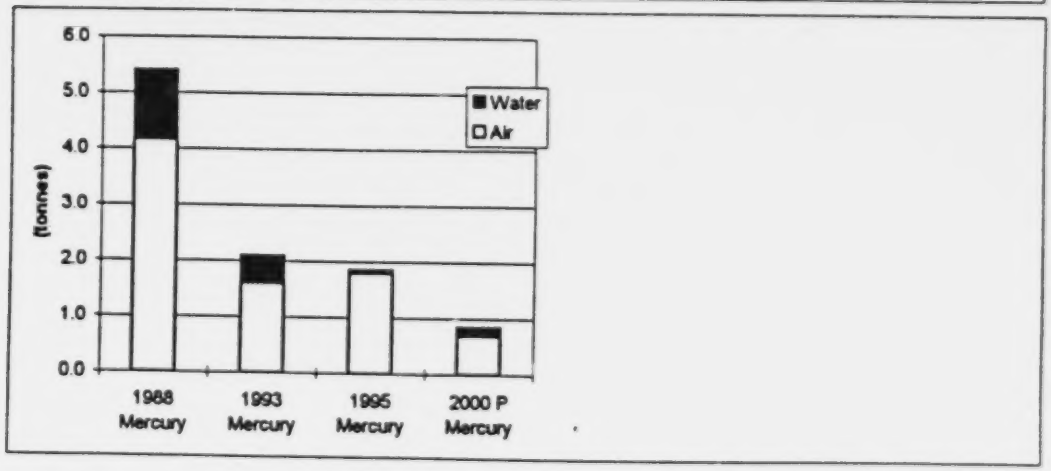
Table A6.1.2 **Releases to Air and Water and Off-site Transfers by Cominco Ltd., Trail, B.C. (tonnes) (Zinc-Lead Smelter/Refinery)**

Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	16.3	7.0	14.9	6.0
Water Releases	28.1	21.0	11.6	1.5
Total Releases	44.4	28.0	26.5	7.5
Transfers Off-site		0.0	0.0	0.0
Cadmium				
Air Releases	3.9	3.0	4.9	0.5
Water Releases	21.0	5.6	2.3	1.1
Total Releases	24.9	8.6	7.2	1.6
Transfers Off-site		0.0	0.0	0.0
Lead				
Air Releases	117.0	83.0	102.7	45.0
Water Releases	258.0	164.0	56.3	20.0
Total Releases	375.0	247.0	159.0	65.0
Transfers Off-site		0.0	0.0	0.0
Mercury				
Air Releases	4.16	1.60	1.80	0.70
Water Releases	1.24	0.50	0.06	0.15
Total Releases	5.40	2.10	1.86	0.85
Transfers Off-site		0.00	0.00	0.00
Nickel				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				

Figure A6.1.3 Cominco Releases to Air and Water







Air

Air emission sources comprise discharges from various sources: major process stacks; a large number of small ventilation point sources; fugitive emissions from process upsets; and fugitive emissions from the storage, handling and transportation of materials.

The new lead smelter will reduce the number of major stacks in the smelter area from four to two and will eliminate the largest source of air contaminants. Discharges from the remaining two stacks will also be reduced. The SO_2-rich off gas from the Kivcet will be integrated into the sulphur gas treatment and acid plants complex on the zinc side. The main zinc stack characteristics will not change significantly, and are already low in metal releases. Because of the ammonia scrubbing system used for SO_2 abatement in the acid plant tail gas, there is no relationship between particulate and metals for this stack. A new baghouse facility in the lead refineries was constructed in 1996 primarily to reduce arsenic emissions from that stack.

The many ventilation sources are mostly very small relative to the main stacks. The more significant of these are monitored and most have a baghouse or other abatement system.

The new smelter will also eliminate the major source of process fugitives: the blast furnaces. Materials storage and handling is being addressed by covering major stockpiles and spray coating smaller and temporary stockpiles. Haul roads are frequently cleaned, and drain to the Effluent Treatment Plant. A truckwash cleans vehicles before they leave the site.

Water

Contaminated process effluents are routed to an Effluent Treatment Plant (ETP) where metals are precipitated and removed. Relatively uncontaminated effluents are collected in several outfalls discharging to the Columbia River. The new smelter will eliminate two of these outfalls, including the one associated with a temporary slag collection system in the smelter that has a residual carry over of granulated slag to the river.

Much of the site is now contained and drained to the ETP. This containment will be further expanded when the old smelter is demolished. There is some seepage from old disposal areas into a nearby stream that flows into the Columbia River. The disposal sites have been reclaimed and a program is underway to intercept and treat the seepage.

There is very little "waste" from the Trail Operations. Fumed tail slag that was previously disposed in the river is now collected and is being used in the manufacture of Portland cement. By-products that presently have little or no marketability (e.g. thallium) are stored in a government approved storage building.

Regulatory and Non-Regulatory Programs

The Trail Operations are regulated under the British Columbia *Waste Management Act*. There are 3 major air permits, 2 effluent permits and several other permits relating to storage facilities. All significant emission and effluent sources have specified limits for particulate and metals, expressed as concentration or loading, or both in the case of effluents. The air permits also prescribe ambient air limits for SO_2 for 3 hour, 24 hour and annual time periods.

Certain emission sources associated with the processing of battery scrap are encompassed within the *CEPA* Secondary Lead Smelter Release Regulation, which requires duplicated monitoring and reporting to Environment Canada. There is extensive consultation between provincial and federal agencies (Environment Canada and the Department of Fisheries and Oceans) and Cominco in establishing permit limits, and in assessing impacts and performance.

Cominco is also subject to *Special Waste Regulations* and *Contaminated Sites Regulations*, under the *Waste Management Act*. These cover the storage, treatment and transport of materials classified as hazardous waste; and also the management and remediation of contaminated sites. Cominco is involved in the Trail Community Lead Task Force, a joint community, government, company process addressing the issue of community contamination and the effect on childrens' blood lead. The Task Force is also initiating a comprehensive health risk assessment project, that includes the other metals associated with the smelter.

Internally Cominco has a comprehensive environmental management program at both the Operations wide level and at the individual plant level. This program combines overall discharge reduction targets for the Operations as a whole, implemented through management plans that include pollution prevention, process modification and control, abatement and containment projects, and management practices. A local Environmental Consultative Committee comprising representatives from various groups provides advice and concerns that assist in prioritizing action and funding decisions. Also, Cominco is one of 7 companies in B.C. participating with B.C. Environment in a Pollution Prevention Demonstration Project as a joint venture to test the implementation of this approach.

Monitoring and Research

Ambient air quality is monitored via a network of 12 stations extending over approx. 60 Km of the Columbia Valley. SO_2 is measured continuously, and together with weather monitoring and continuous monitoring of the main stacks, provides the basis for a systematic sulphur control regime. Particulate monitoring is carried out weekly and compared against the B.C. Pollution Control Objectives for the Mining and Smelting Industry, for both particulate and metals. The monitoring network also includes dustfall, sulphation plates and fluoride plates. A recent innovation is the establishment of 60 lichen bio-monitoring sites, and 100 characterized sites to monitor tends in forest re-growth.

The Trail Lead Program, in conjunction with Cominco conducts dustfall monitoring at a network of sites throughout the Trail community, and also periodic sampling of soil, air, dustfall, and house dust at several "sentinel homes" around the community.

Cominco also have a very comprehensive program to monitor workplace exposure levels, and biological levels to confirm the effectiveness of control programs.

All outfalls to the Columbia River are monitored daily for all elements of significance. The river itself is sampled regularly at several sites above and below the Operations. Cominco, with other industry and government parties (federal and provincial), participated in a major cooperative study of the river in 1993 to evaluate its environmental health (Columbia River Integrated Environmental Monitoring Program - CRIEMP). In 1995 the Company conducted a follow-up study, combining chemical and biological measurement techniques.

Several old stockpiles of arsenic/antimony material have been reclaimed to contained storage facilities. The old area is being characterized with regard to contamination and ground water seepage with a view to intercept and treat.

The Research Dept. of Cominco has an Environment Section that investigates and pilots technological innovations to improve processes and the measurement, control and recycling of contaminants. The research efforts of Cominco over the years have led to many technological breakthroughs that have improved environmental performance and reduced or eliminated sources of pollution (e.g. development of granulated ammonium sulphate fertilizer in 1995 that enabled the Phosphate Plant to be shutdown, eliminating a source of metals and nutrient releases to the river).

Programs and Plans

1988 on Upgraded materials storage, handling & transport to reduce fugitive dust and prevent off-site tracking. Includes haul road paving and drainage to effluent treatment plant; covering of major stockpiles and spray coating of active stockpiles; improved

management of handling and transport practices; more intensive road washing and sweeping; truck wash facilities (now being upgraded to all-season facility); construction of private vehicle road to avoid tracking of contaminants off-site.

1993 Installation of heat exchanger system to eliminate contaminants from direct water cooling of sinter off-gas (07 Sewer Project)

Minor zinc operations effluent control projects completed (ARET Action Plan)

1994 Construction of major effluent treatment plant storage lagoon (ARET Action Plan)

Roaster start-up stack emissions control implemented (ARET Action Plan)

Emission & Effluent Management Plans submitted to the government (Annual Report 1993)

Effluent plan includes development of lagoon for the Effluent Treatment Plant, surface drainage capture and treatment, reduction in outfall contaminants was predicted and Outfall 07 was to be eliminated (Annual Report 1993)

Emissions Management Plan includes improving the level of air emissions from the existing smelter facility pending modernization. Pursuing opportunities to improve controls further through application of continuous emissions monitoring. Plans for upgrading the storage facilities for intermediate materials (Annual Report 1993)

Construction of a major effluent treatment plant storage lagoon completed and operational. Additional surface drainage captured in lagoon

One Roaster start-up stack emission control implemented

1995 Remaining Roaster start-up stack emission control implemented

Fumed slag discharge to Columbia River eliminated in July

1995 Granulated ammonium sulphate process successfully started. Phosphate plant shut down, eliminating source of nutrients and metals to the Columbia River.

1996 Lead Refinery, additional baghouse capacity installed and scrubber revisions completed in June

1997 Completion of Lead Smelter Modernization Project with commissioning of Kivcet (ARET Action Plan)

Issues

Cominco is far from coastal ports. Transportation of feed materials and products is a major cost that is partly offset by lower power cost from company-owned hydroelectric power generating facilities. Since product price is not a variable that Cominco can

control, the focus is on efficiency and cost of production. The Sullivan Mine is scheduled to close within the next few years, which will significantly add to the transportation costs to import alternative concentrates.

The Trail Operations went through a major restructuring over the past few yeas, with employment levels reduced by 40 percent, and several other measures taken to improve efficiency. These were necessary for the survival of the Operation after years of financial losses. The failure of the QSL smelter in 1990 was a major technical, financial and environmental setback.

Despite these difficulties it was over those same years that major improvements in environmental performance were realized. Trail is now a profitable operation, with plans to incrementally increase production as opportunities are identified. Through the environmental management process, Trail Operations is developing a longer term plan that will meet the requirements and aspirations of the various community and government stakeholders, in accordance with priorities and a schedule that will be agreed with them. Key to achieving these environment, productivity and cost objectives is the new lead smelter that will startup in the first quarter of 1997.

Technical Options To Achieve Further Release Reductions

After the new lead smelter is up to full operation, a new baghouse facility will be installed on the old site to replace the existing slag fuming baghouse. A review of the entire operations will be conducted to confirm attainment of performance expectations, and to identify opportunities to achieve further improvements once the modified departments of by-product materials are established.

During this review period, a comprehensive evaluation of air and water quality effects will be carried out. The air data will be incorporated into the assessment program carried out by the Trail Community Lead Task Force to determine the effectiveness of the performance improvements in achieving acceptable health levels in the community and the need for further improvements. Effluent reductions will target attainment of water quality objectives close to the outfalls in the Columbia River and non-toxic discharge criteria, both through a combination of prevention, control, containment and treatment upgrades.

Further work to reduce fugitive dust from the storage, handling and transportation of materials is planned. The new smelter assist in reducing fugitive emissions from materials storage as major stockpiles of materials that previously accumulated due to imbalances between the modernized zinc operations and the old lead smelter will gradually be reprocessed.

Consideration will be given to improvements in emission sources on the zinc side, but these are not relevant to the *CEPA* Substances.

6.2 SHERRITT INTERNATIONAL CORPORATION METALS REFINERY (COBALT REFINERY COMPANY) FORT SASKATCHEWAN, ALBERTA

Profile

Sherritt International Corporation operates in Canada, the Republic of Cuba, and internationally. The Corporation's business areas include metals, fertilizers, and oil and gas.

Sherritt International Corporation owns 50% of a vertically integrated commodity nickel and cobalt business. This metals enterprise consists of three companies:

- Moa Nickel S.A. has mining and associated processing facilities at Moa Bay, Cuba;
- International Cobalt Company Inc. of Nassau, Bahamas is the worldwide sales and marketing organization; and
- The Cobalt Refinery Company Inc. (Corefco) owns and operates the Metals Refinery at Fort Saskatchewan, Alberta.

Together, these three companies are known as the "Metals Enterprise".

Sherritt International is also the sole owner of an engineering and technology business based in Fort Saskatchewan.

Sherritt International explores for, develops, and produces oil and natural gas reserves worldwide. In addition to its tourism and agriculture assets in Cuba, Sherritt International Corporation plans to expand its investment base to include other industries which are fundamental to Cuba's economic growth and development.

Sherritt International Corporation is the sole owner and operator of facilities producing fertilizers as well as providing utilities and services for the Metals Enterprise. These facilities are:

- Ammonia Utilities (Ammonia I Plant, Utilities I Plant, and effluent management system); and
- Chemical Utilities (Urea I Plant, Phosphate Plant, Sulphuric Acid Plant, and Fertilizer Loadout).

Further discussion of Sherritt International activities concerns only the Fort Saskatchewan Metals Refinery operated by Corefco.

Sherritt International Corporation (Sherritt) currently refines approximately 27,500 tonnes of nickel and 2,500 tonnes of cobalt annually. The refinery's product is sold world wide to the chemical market, stainless steel industry, powder metallurgical industry, and various other markets.

In 1955, the original refinery was commissioned. The original refinery consisted of the Leach, Copper Boil, Metals Recovery, Sulphide Precipitation, and Ammonium Sulphate circuits. The 1956 production capacities for nickel and cobalt were 7,400 and 77 tonnes respectively.

In 1992, the refinery was expanded and the Cobalt Separation, Cobalt Recovery, and Ammonia Recovery Circuits were constructed. The Cobalt Separation and Recovery circuits increased the refinery throughput to its current capacity, while the Ammonia Recovery Circuit improved the environmental performance of the refinery.

In 1996, a further expansion was undertaken to increase the capacity to 27,500 tonnes per year nickel and 2,500 tonnes per year cobalt.

The Metals Refinery produces two products, three by-products, and one waste. The products are pure nickel and pure cobalt. The by-products include ammonium sulphate, copper sulphides, and zinc sulphides. The waste includes solid tailings from the refining process.

Table A6.2.1 Production Summary (tonnes)

Products	1988	1993	1995	2000 (Projected)
Nickel	24,220	18,350	23,350	27,500
Cobalt	925	1,220	1,730	2,500
Copper[1]	575	690	325	260
Zinc Sulphide[2]	0	210[3]	952	315
Ammonium Sulphate	140,000[3]	110,000[3]	136,000	150,000

1 as copper sulphide
2 commercial production began in 1993, inventory depletion through 1995/96
3 estimated

Process Description

The refinery consists of eight operating circuits and they are Leach, Cobalt Separation, Copper Boil, Metals Recovery, Cobalt Conversion and Reduction, Sulphide Precipitation, Ammonium Sulphate, and Ammonia Recovery Circuits. A simplified block flow diagram of the Metals Refinery is shown in Figure A6.2.1.

The simplified overall reactions for producing pure nickel are as follows:

Leaching Step: $NiS + 2O_2 + 6NH_3 \rightarrow Ni(NH_3)_6SO_4$

Reduction Step: $Ni(NH_3SO_4)_2 + H_2 \rightarrow Ni^\circ + (NH_4)_2SO_4$

The simplified overall reactions for producing pure cobalt are as follows:

Leaching Step: $2CoS + 9/2\ O_2 + 10\ NH_3 + H_20 \rightarrow 2Co(NH_3)_6^{3+} + 2SO_4^{2-} + 2OH^-$

Reduction Step: $Co(NH_3)_2SO_4 + H_2 \rightarrow Co^\circ + (NH_4)_2\ SO_4$

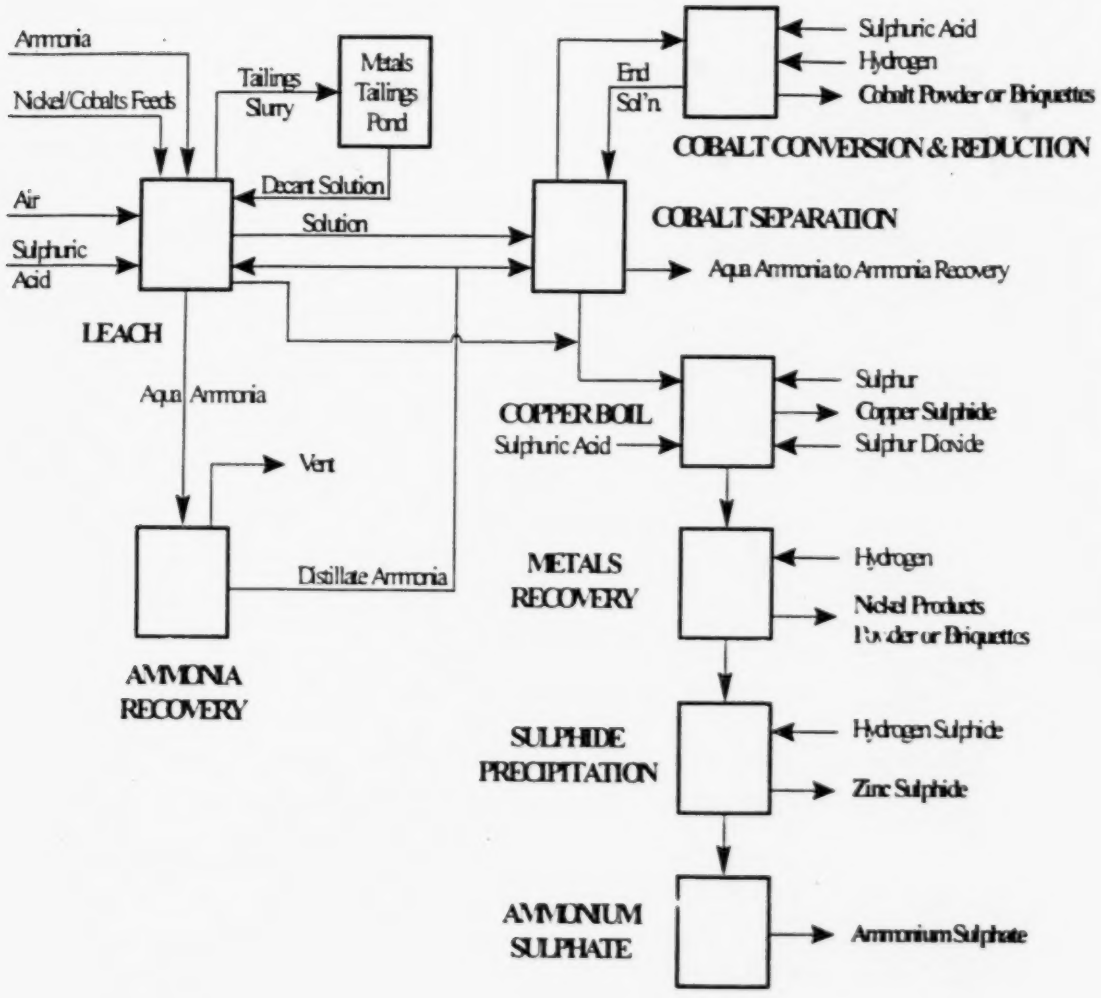
There are three leach circuits in the Leach Plant. These are the Hexamine, Adjustment, and Final Circuits. The purpose of the leach circuits is to dissolve the metals that are present in the unrefined metal ore. Prior to entering a leach circuit, the nickel feed is segregated into high and low cobalt content feeds.

The high cobalt feed materials are blended with ammonium sulphate liquor and pumped to the Leach Hexamine autoclave circuit. Along with the mixed solution, air and ammonia are added to the autoclaves. In the autoclaves, at elevated temperature and pressure, the leach reactions occur. The majority of the metals sulphides, oxygen, and ammonia react to form a soluble nickel and cobalt hexamine complex.

The resulting slurry is pumped into a lamella thickener where solids are separated from the leach liquor. The solids are recycled to the Adjustment Leach circuit. The Leach liquor, which contains the hexamine complexes, is pumped to the Cobalt Separation Circuit. The autoclave vents are sent to the Tail Gas Scrubber for ammonia recovery.

The low cobalt feeds that are primarily nickel matte, are sent directly to the Adjustment Leach circuit for metal recovery. The matte ammonium sulphate and recycle solution are fed into a tank. The mixed solution is pumped into the autoclaves where ammonia, air, and other reagents are added. In the pressurized and heated autoclaves, the nickel leach reaction occurs to form primarily nickel amine. The resulting slurry is pumped into a lamella thickener and the solids are separated from the leach liquor. Any solids remaining are sent to the Final Leach Circuit and the adjustment leach liquor is sent to the Copper Boil Circuit. The autoclave vent gases are sent to the Tail Gas Scrubber for ammonia recovery.

Figure A6.2.1 Sherritt Process Flow Sheet.



The solids from the Adjustment Leach Circuit are sent to the Final Leach Circuit. The Final Leach process is similar to the Hexamine and Adjustment Leach. In the autoclaves, any remaining metals are extracted and a final iron oxide residue is produced. The autoclave slurry is sent to thickeners and a centrifuge where the solids and liquids are separated. The liquid is recycled to the process and the residue is sent to the Metals Tailings Pond. Carrier water, tailings pond return, is used to transport the residue to the Metals Tailings Pond. Sulphuric acid is added to the tailing pond carrier water to minimize the ammonia losses in the tailings pond.

The leach liquor from the Leach Hexamine Circuit is processed in the Cobalt Separation Circuit to separate the nickel and cobalt. The nickel bearing solution is sent to the copper boil circuit in the Leach Plant. The pure cobalt rich solution is sent to the Cobalt Conversion and Reduction Circuit to produce cobalt powder.

All tanks and filter vents in this circuit are sent to the Cobalt Separation Scrubber and the ammonia present in the vent gases is recovered and sent to the Ammonia Recovery Circuit.

Nickel rich leach liquor from the Adjustment Leach Circuit and the Cobalt Separation Circuit is processed in the Copper Boil Circuit. The purpose of this unit is to remove the dissolved copper from the nickel rich solution.

The nickel rich feed liquor is heated in a nickel boil column and ammonia is vaporized. The ammonia is condensed and the aqua is sent to Ammonia Recovery. The resulting liquid is heated in the copper boil pots where the sulphur compounds react to form copper sulphides solids. Sulphur and sulphur dioxide are added to assist this reaction. The resulting slurry is pumped to a lamella thickener. The clarified liquid is filtered and the copper free filtrate is sent to Metals Recovery to produce pure nickel product. The separated solids are combined with the lamella solids and are then washed and filtered. The washed filtrate is reused by the process and the solids, copper sulphides, are sent to customers.

The Metals Recovery Circuit is comprised of three main areas for the production of nickel powder or briquettes. These areas are comprised of the Oxydrolysis, Nickel Reduction, and the Metals Handling Circuits.

The Oxydrolysis Circuit oxidizes all of the unsaturated sulphur compounds and sulphamates from the feed solution received from the Copper Boil Circuit. Ammonia is added to the copper boil solution in the adjustment tank to control the molar ratio of the solution. This solution is heated and transferred to the Oxydrolysis tower. In the Oxydrolysis tower, the unsaturated sulphur based compounds are oxidized to minimize the sulphur content of the nickel product.

In 1997, a project will be implemented to recycle the Oxydrolysis tower vent gas (spent air) to the Leach autoclaves. This will eliminate ammonia emissions from this source and reduce the energy required for air compression.

The purified solution from the Oxydrolysis Circuit is transferred to the Nickel Reduction Circuit. Ferrous sulphate and nickel solution are added to create a fine nickel powder seed in the autoclaves at the beginning of a production cycle. The purified solution and hydrogen are added to the autoclaves and the autoclaves are agitated. The nickel amine complex reacts with the hydrogen and produces nickel metal and ammonium sulphate. The nickel is deposited onto the nickel powder seed. When the precipitation is complete, the depleted solution is drawn off and fresh solution is added. This cycle is repeated until the nickel particles meet production specifications.

The slurry is then discharged into flash tanks. The vent from the tanks vent to the atmosphere. The solution from the flash tank, known as reduction end solution, is sent to the Sulphide Precipitation Circuit for additional metals recovery. The nickel powder, from the flash tank, is transferred to a pan filter and the nickel particles are washed with water. The nickel powder is then dried and sent to the Metals Handling Circuit. In the Metals Handling Circuit, the nickel is either packaged in powder form or compacted into briquettes, sintered, and packaged.

In the Cobalt Conversion and Reduction Circuits, the solution from the Cobalt Separation Circuit, sulphuric acid, and cobalt powder are added to the conversion tanks. The cobalt is present in the cobaltic (+3) state and is reduced to the cobaltous (+2) state. The resulting solution is filtered. The solids, a cobalt cake, is returned to the leach circuit for further processing. The filtrate is sent to the reduction autoclaves.

The reduction of cobalt to the solid state occurs as a batch operation in a reduction autoclave. Nucleation catalyst (fine cobalt powder) and cobalt solution are added to create a fine cobalt powder seed at the beginning of each production cycle. Converted solution and hydrogen are added to the autoclave and the autoclave is agitated. The aqueous cobalt compound reacts with hydrogen to produce cobalt metal and ammonium sulphate solution. The solid cobalt precipitates out on the cobalt seed.

The autoclave slurry is then discharged into a flash tank. From the flash tank, the cobalt powder is transferred to a pan filter where the cobalt particles are washed. The powder is then dried and sent to the Metals Handling Circuit. In the Metals Handling Circuit, the cobalt is either packaged in powder form or compacted into briquettes, sintered, and packaged. The solution from the flash tank known as reduction end solution is recycled to the process. Vapors from the autoclave are vented to the flash tank. Vapors from the flash tank are passed through a condenser before being vented to the atmosphere. The condensed aqua solution is recycled to the process or sent to the ammonia recovery circuit.

Reduction end solution from the Metals Recovery Circuit still contains some nickel, cobalt, and zinc. The purpose of the continuous Sulphide Precipitation Circuit is to remove all metal ions from the solution.

The Sulphide Precipitation Circuit is a two stage process. First, the zinc is precipitated and then the mixed nickel and cobalt is removed in the second stage. In the zinc precipitation tank, hydrogen sulphide gas is added to the liquor and the zinc forms insoluble zinc sulphides. The resulting slurry is passed through a lamella thickener. The solid zinc sulphides are washed, settled, and filtered. The zinc sulphide is sold offsite for further reprocessing. The clarified lamella solution is pumped to the second stage. In the mixed sulphide precipitation tank, hydrogen sulphide and ammonia are added to the solution and insoluble metal sulphides are formed. The resulting slurry is settled in a lamella thickener. The solution, that contains mainly ammonium sulphate, termed barren liquor, is filtered and pumped to the Ammonium Sulphate Circuit. The solids are sent to the Leach Circuit for further processing.

The chloride purge from the Ammonia Sulphate Circuit is also treated in this unit. Hydrogen sulphide and chloride purge solution are reacted in a precipitation tank to from metal sulphides. The resulting slurry is separated and the solids are sent to the Leach Circuit for further processing and the liquids are sent to the Chemical Utilities Phosphate Plant to produce 19-2-0-22 fertilizer.

Precipitation tanks vent into the Hydrogen Sulphide Vent Scrubber. In this scrubber, the hydrogen sulphide is recovered from the vent gases by scrubbing with a dilute aqua ammonia solution. The resulting scrubbed gases are burned by natural gas (methane) in the Hydrogen Sulphide Scrubber Flare Stack.

Lamella thickeners and wash tanks vent into the Venturi Scrubber. In this scrubber, hydrogen sulphide is removed from the gas and then the gases are burned to convert the residual hydrogen sulphide to sulphur dioxide using natural gas (methane) in the Hydrogen Sulphide Scrubber Flare Stack.

The Ammonium Sulphate Circuit recovers the ammonium sulphate crystals from the barren liquor using a series of crystallizers. Barren liquor from the Sulphide Precipitation Circuit is heated and enters the crystallizer. In the crystallizer, water is evaporated and ammonium sulphate crystals form. Ferrous sulphate is added to the crystallizers to enhance the formation of crystals. The resulting slurry is sent to the centrifuges where excess solution is then removed. The crystals are then fully dried in dryers. The dryer exhausts into a knock out vessel. Dust collected in the tank is dissolved and recycled to the process. The gases then exhaust to the atmosphere via a stack. The sulphate product is sold as fertilizer. The evaporated water is condensed and recycled to the process or disposed of in the effluent sewer.

Intermittently, solution is purged from the feed tank to remove excess chlorides from the system. Chlorides are one impurity in the matte feedstock. This solution is sent to the Sulphide Precipitation Circuit for further processing.

The water collected in the well for the condensers (commonly known as Hotwell) is recycled to the Metals Operations where it is used in a number of locations. The excess is discharged to the storm pond so that it can be treated to remove its ammonia content.
The Ammonia Recovery Circuit is used to recover and recycle ammonia from the other circuits.

Ammonia laden atmospheric vent gases from the Copper Boil Circuit and Leach Circuits are scrubbed with water in the Vent Gas Scrubbers. The ammonia present in the vent gases are absorbed by the water. The scrubbers vent to the atmosphere and the resulting ammonia water solution is sent to the aqua storage sphere.

Ammonia laden pressurized vents from the leach autoclaves are scrubbed with water in the Tail Gas Scrubbers. The ammonia present in the vent gases are absorbed by the water. The scrubbers vent to the Still Bottoms Evaporator and the resulting ammonia water solution is sent to the aqua storage sphere #2.

The ammonia rich vents from the Cobalt Separation and some Cobalt Conversion and Reduction vents are scrubbed with water in the Cobalt Separation scrubber. The ammonia present in the vent gases are absorbed by the water. The scrubber vents to atmosphere and the resulting ammonia water solution is sent to the aqua storage sphere #2.

Solution from the #2 storage sphere is pumped into the High Pressure Still. In the still, the solution is heated and the ammonia is evaporated. The ammonia is condensed, stored in an ammonia storage drum, and is reused in the process. The resulting liquid stream is pumped to the Still Bottoms Evaporator and is reused in the process.

The Tail Gas Scrubber vent gases and the High Pressure Still liquid stream enter the Still Bottoms Evaporator. In the evaporator, some of the water is evaporated and vented to the atmosphere. The resulting evaporator bottoms solution is reused by the process.

Releases

All point source releases to air and water from the Metals Refinery are shown in Figure A6.2.1. Because the Metals Refinery uses a "state of the art" hydrometallurgical process, there are no significant metals emission from point source stacks. The only fugitive dust emissions occur in the feed handling area. Fugitive emissions from materials handling and storage are minimized by engineering controls and best

management practices. All feed materials arrive in bulk bags and are unloaded and stored in enclosed buildings. Equipment and procedures have been modified to reduce fugitive emissions and worker exposure. The feed materials are normally transported as a slurry or via enclosed conveyors. The site is paved and a street sweeper is used to keep working areas in the buildings and roadways free of dust.

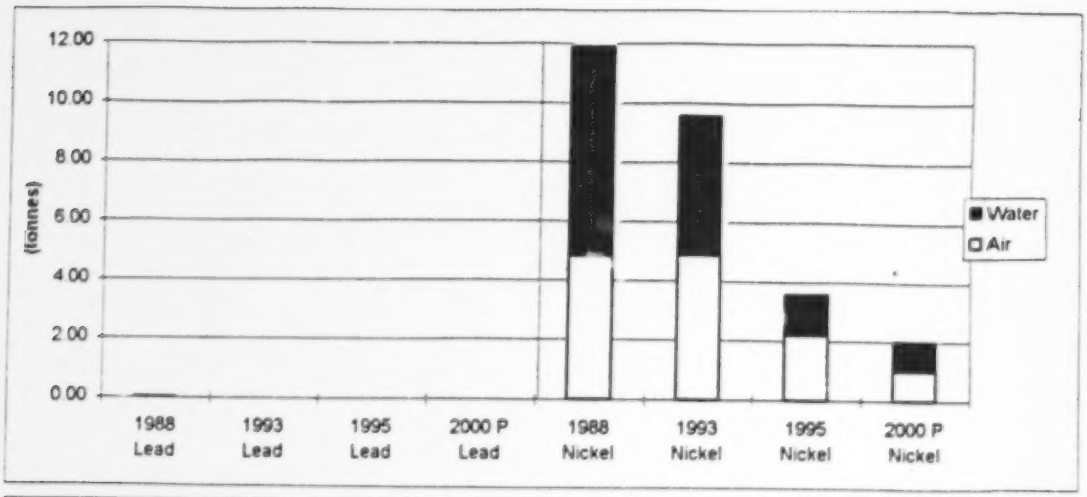
There are no discharges of metal bearing solutions from process facilities into the effluent system. The only process discharge is hotwell condensate containing a small amount of ammonia. Most of the contained ammonia is removed in a downstream ammonia recovery unit. Site runoff containing dissolved metals (primarily nickel) due to historical spills and soil contamination is treated in a liming facility where 90% of the nickel is removed. The amount of nickel appearing in site runoff water has decreased by 50% since 1993.

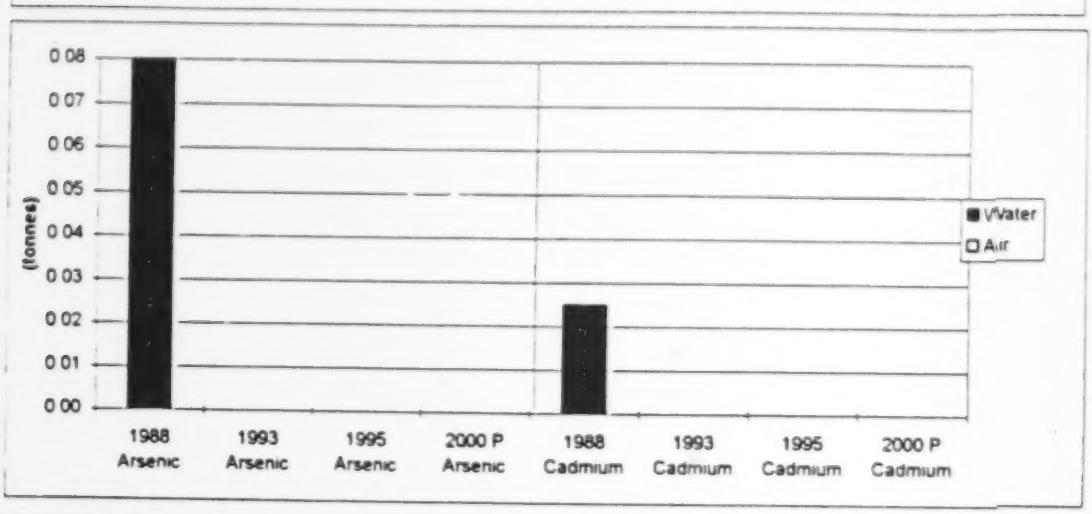
Selected release data for the period 1988 to 1995 are presented in Table A6.2.2 and Figure A6.2.2 and projected levels for the year 2000 are included. Releases of *CEPA* substances to air and water have decreased by 70% from 1988 to 1995 and further reductions are projected.

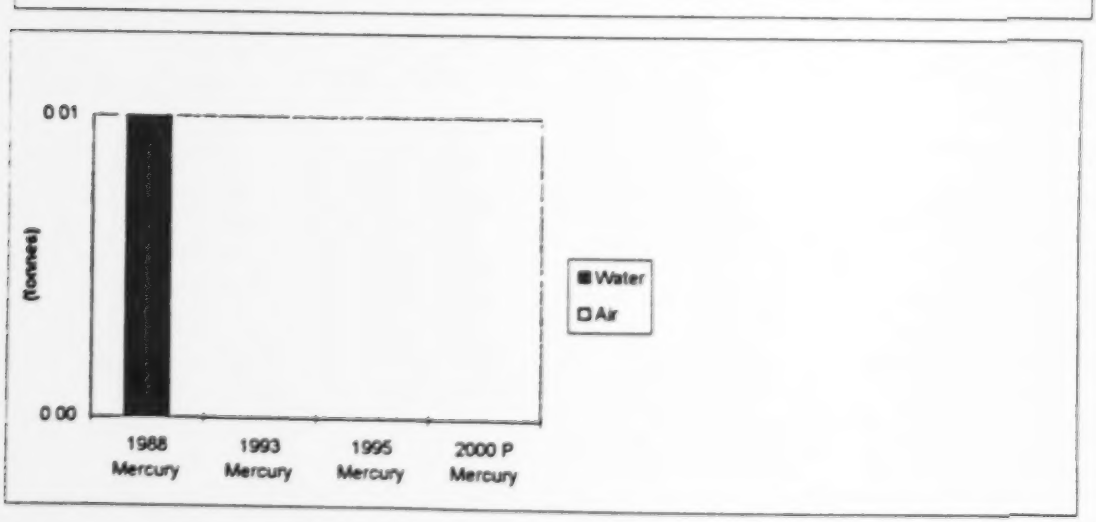
Table A6.2.2 **Releases to Air and Water and Off-site Transfers by Sherritt, Fort Saskatchewan, Alberta (tonnes) (Nickel Refinery)**

Year	1988	1993	1995	2000 P
Arsenic				
Air Releases				
Water Releases	0.08			
Total Releases	0.08			
Transfers Off-site				
Cadmium				
Air Releases	0.00			
Water Releases	0.03			
Total Releases	0.03			
Transfers Off-site				
Lead				
Air Releases				
Water Releases	0.01			
Total Releases	0.01			
Transfers Off-site				
Mercury				
Air Releases	0.00			
Water Releases	0.01			
Total Releases	0.01			
Transfers Off-site				
Nickel				
Air Releases	4.8	4.9	2.2	1.0
Water Releases	7.1	4.7	1.4	1.0
Total Releases	11.90	9.57	3.58	2.00
Transfers Off-site		23.0	14.9	7.4

Figure A6.2.2 Sherritt Releases to Air and Water







Regulatory and Non-Regulatory Programs

The Metals Refinery is regulated by the Alberta Environmental Protection and Enhancement Act. The Operating Approval for the Refinery has set legally enforceable daily and monthly quantities for metals (Cr, Ni, and Cu) and Total Suspended Solids (TSS) that can be present in the final effluent from the Fort Saskatchewan plant site. As well, there are daily and monthly limits for NH_3-N, Org-N, PO_4, CN_{TOTAL}, and pH in the site effluent. The effluent is tested monthly by the 96-hr Multiple Concentration Acute Lethality Test using Rainbow Trout and immediate action must be taken to eliminate the cause of the acute lethality whenever there is 50% or less survival in the 100% test sample.

With respect to air emissions, the Operating Approval has established legally enforceable limits for ammonia, sulphur dioxide, and particulates. The major ammonia sources are equipped with continuous emission monitors for ammonia.

The following continuous improvement programs are in progress as per the requirements of the Operating Approval:

- Air Emissions Reduction Program;
- Zero Contaminant Discharge Plan (effluent); and
- Secondary Spill Containment Program.

Monitoring And Research

Although the flare stack from the Sulphide Precipitation Plant is regulated for SO_2, annual testing is not required by the Operating Approval. However, this source is tested periodically for process control reasons. The feasibility of installing a Continuous Emission Monitor on this source is being pursued. There are no point sources of *CEPA* toxic substances in the Metals Refinery. Dust levels in the feed handling area are measured several times each year. These measurements are used to calculate fugitive emissions. All other point sources (stacks) within the Metals Refinery are tested annually (three major sources are tested quarterly) for ammonia. These sources are equipped with Continuous Emission Monitors for ammonia.

Three perimeter ambient air monitoring stations monitor NH_3, NO_x, SO_2, and meteorological conditions in compliance with the Operating Approval. As well, two continuous path systems monitor ambient ammonia and hydrogen sulphide between the plant site and the populated area southwest of the site and the industrial area east of the site.

Site effluent is rigorously controlled and monitored through an effluent management system which includes sewer systems, effluent retention ponds, a facility to treat surface runoff for removal of metals, ammonia, and phosphate, onstream analysis of inputs to the effluent system and continuous sampling and flow measurement of critical effluent flows.

In addition to these initiatives, the company participated in a detailed study called the Joint Industrial - Municipal North Saskatchewan River Study. The study was initiated by a group of eleven Edmonton and Fort Saskatchewan area industries and municipalities that discharge effluent to the river. This study was initiated in 1991 with sampling programs in 1992, 1993, and 1994. The complete study was released to the public and submitted to Alberta Environmental Protection in 1995. It evaluated the water quality and environmental integrity of the North Saskatchewan River (NSR).

Programs and Plans

1988	Began installation of groundwater monitoring network.
	Began investigating feasibility of continuous emission ammonia monitors for Leach Plant sources.
	Completed installation of weeping tile groundwater intercept system on Metals Tailings Pond.
1989	Completed construction of effluent retention ponds.
	Installed continuous emission monitors for ammonia on the two Leach Plant stacks.
1990	Completed construction of a second storm water retention pond.
	Installed multi-point monitoring system for H_2S on eastern boundary of plant site.
1993	Installed liming plant to remove metals and phosphate from storm (surface runoff) water.
1994	Switched from chromate/zinc based to phosphate based corrosion inhibitor in cooling water system.
1995	Installed first ammonia recovery unit to remove ammonia from storm water.
1996	Installed second ammonia recovery unit.
	Stopped all direct waste water discharges to the effluent sewers from the Metals Operation except for the Ammonium Sulphate Plant hotwell condensate.
	Maximized internal effluent recycling.
	Completed testing of reverse osmosis for purifying hotwell condensate.

1996 (cont'd)	Completed study on converting tailings pond to dry-stacking.
	Completed study on Zero Effluent Discharge for Metals Refinery (including capture and recycle of all surface runoff).
	Leased new street sweeper for maintaining feed handling areas.
1997	Evaluate schedules for the Zero Effluent Discharge Plan and conduct detailed design of tailings dry stacking.
	Complete feasibility study on Continuous Emission Monitor for Sulphide Precipitation Plant stack and install/commission if practicable.
	Implement Environmental Control module of Safety Management Practices program.
	Implement a project to recycle Oxydrolysis tower vent gas (spent air) to the leach autoclaves to reduce ammonia emissions and reduce energy costs.

Issues

- Need for continued improvement to maintain or improve competitive position and generate cash to fund new investment.
- Prioritization of health and environmental risk reduction opportunities.
- Balancing requirements of federal and provincial environmental, health and safety regulations.

Technical Options to Achieve Further Release Reductions

The Metals Refinery uses a "state-of-the-art" hydrometallurgical process, hence, there are no metals emissions from point sources. The only fugitive dust emissions occur in the feed handling facility.

There are no direct discharges of metals bearing solutions from process facilities into the effluent system. Historical spills and soil contamination are the sole sources of metals in the plant effluent. The site runoff is currently treated by a liming facility to remove more than 90% of the nickel.

Technical options to achieve further release reductions include continuous improvement of engineering controls and best management practices, continuous improvement of secondary containment systems and capture and recycle of Metals Refinery surface runoff to enable Zero Effluent Discharge from the Metals Refinery or further treatment of site effluent such that is not toxic to the river biota.

6.3 HUDSON BAY MINING & SMELTING CO. LTD. FLIN FLON OPERATIONS FLIN FLON, MANITOBA

Profile

Hudson Bay Mining & Smelting Co. Ltd. (HBM&S) operates a mill, copper smelter, and zinc plant at a metallurgical complex in Flin Flon, Manitoba. Copper and zinc ores from surrounding mines have been processed at the facility since 1930. The zinc refinery was originally based upon a roast-leach-electrowinning process, but in 1993 was converted to the world's first commercial application of the Sherritt two-stage pressure leach process. The copper smelter uses pyrometallurgical processes. HBM&S produces copper, zinc, and secondary metals such as cadmium, gold, and silver.

Process Description

Flin Flon Mill

Broken ore from mines is passed through a gyratory crusher and then through two cone crushers. Crushed ores are ground first in rod and then ball mills. Concentrates are formed by passing ground ores through flotation cells for the sequential removal of copper and zinc sulphide minerals from gangue minerals. Dewatering of the concentrates occurs in a series of thickeners and filters. The gangue minerals (tailings) are pumped to a tailings pond.

The tailings pond consists of three separate units - primary and secondary settlement ponds and a final clarification pond. Water levels, and therefore residence time and settling, are manipulated in each pond by control structures at each outlet. Water treatment is accomplished by raising the pH by lime addition. This causes the formation of metal hydroxides which subsequently settle out.

Copper Smelter

The smelter treats copper concentrates along with recycle residues and flux. Total feed to the roasters is 1,300 tonnes per day of concentrate, flux, and recycled dust, with dust totalling 45 tonnes per day.

The feed is blended and charged to multiple hearth roasters where it is dried and partially oxidized. The roaster product (calcine), recycle dust and converter slag are smelted in a reverberatory furnace. This operation separates the bulk of the non-sulphide gangue and flux in a molten slag waste which is periodically removed from the reverberatory furnace. The copper and iron sulphide minerals form a molten matte which separates below the slag because of its higher density.

Figure A6.3.1 **Hudson Bay Mining & Smelting Copper Smelter Process Flow Sheet**

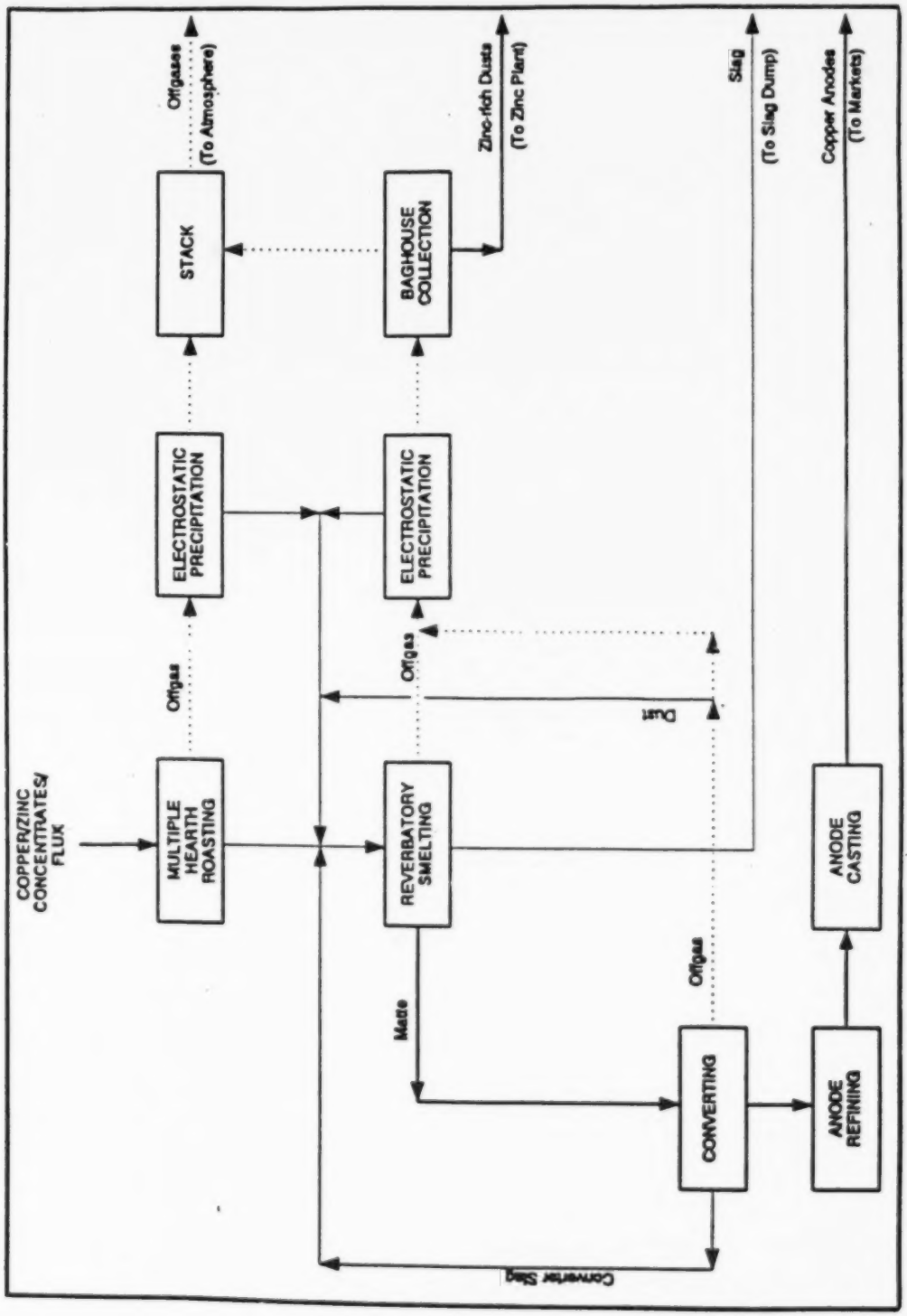
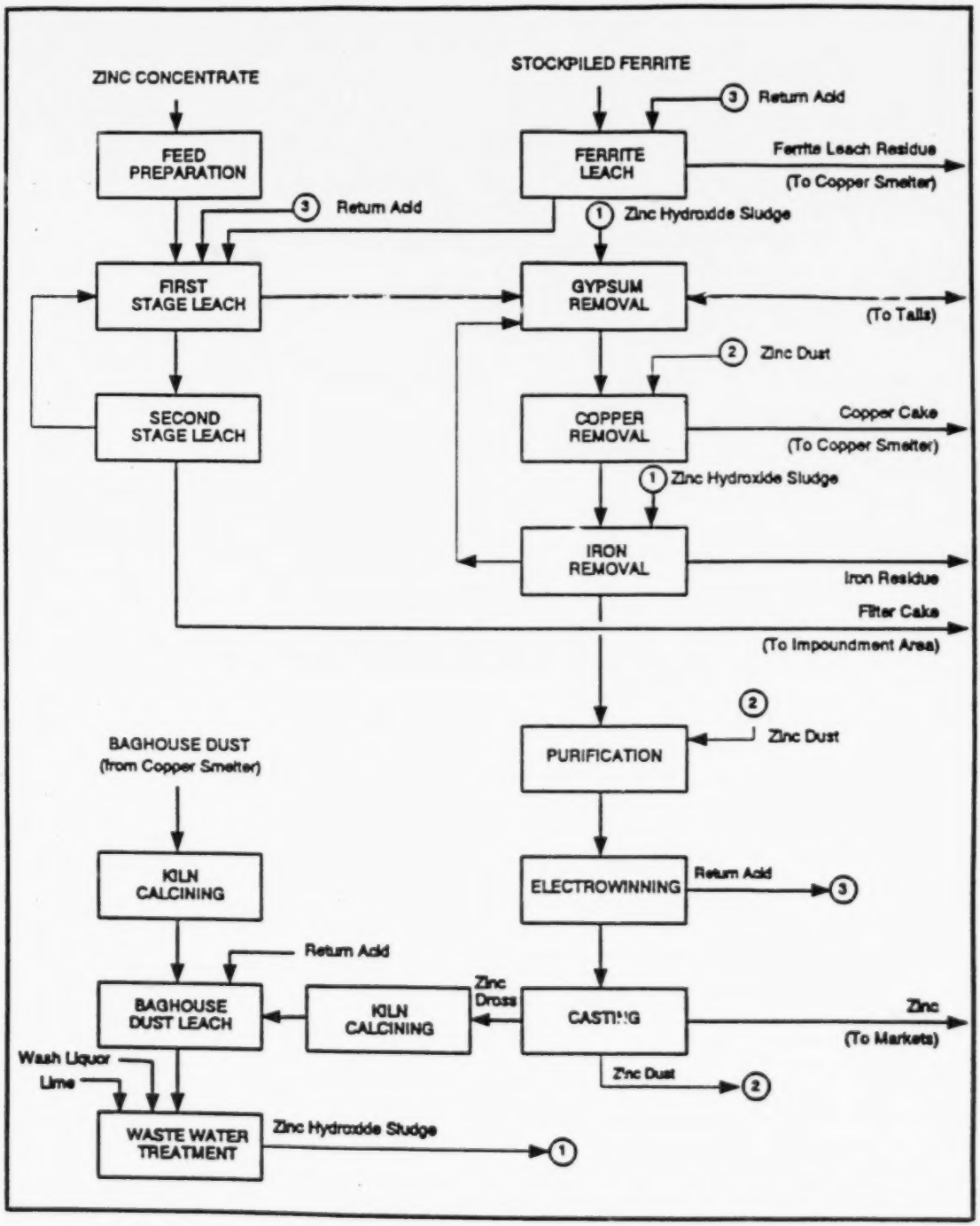


Figure A6.3.2 Hudson Bay Mining & Smelting Zinc Plant Process Flow Sheet



The matte is then processed in Pierce-Smith converters on a batch basis with air to convert the iron sulphide to iron oxide. Iron oxide combines with added flux to form a slag which separates from the copper sulphide. This slag is recycled to the reverberatory furnace where its relatively high copper content is reduced as it mixes with the slag formed in the reverberatory furnace. As the converting operation continues, the copper sulphide is converted to blister copper, which contains only small quantities of sulphur and oxygen. The conversion of sulphides to oxides with air produces converter offgases containing sulphur dioxide.

The blister copper is treated in an anode refining furnace which removes most of the small quantities of oxygen and sulphur remaining in the copper. The blister copper is cast into anodes which then have the proper composition and shape for electrorefining. Anodes are shipped to an external copper refinery for electrolytic refining.

Zinc Plant

Zinc concentrates are processed in the zinc pressure leaching facility along with zinc ferrite residue from the former calcine leaching circuit.

The zinc concentrate is reground and transferred to a two stage pressure leaching process, in which partially leached concentrates are autoclaved with fresh return acid and partially neutralized return acid is autoclaved with fresh concentrates. The second stage pressure leach underflow is filtered and washed before being directed to an impoundment area. This material may be treated in the future for recovery of sulphur, precious metals or both.

The pressure leach liquor is partially neutralised by zinc hydroxide sludge in a step referred to as gypsum removal. Copper is removed from the partially neutralised pressure leach liquor by cementation with zinc dust. This copper removal liquor is then transferred for further neutralisation to precipitate residual iron. The iron removal liquor is then purified with zinc dust and transferred to electrowinning wherein the zinc is electrodeposited, regenerating sulphuric acid. The removed zinc is melted, alloyed, and cast for sale.

Return acid (spent electrolyte) from electrowinning is recycled to the pressure leaching stages, and to the atmospheric ferrite leach step. The latter treats a stockpile of ferrite residue. The upgraded ferrite leach residue is treated in the copper smelter for precious metal recovery while the ferrite leach liquor is directed to the first stage pressure leach.

Baghouse dust from the copper smelter and zinc casting plant dross are passed through a kiln for halogen removal and then leached in a small quantity of return acid. The baghouse dust leach liquor is combined with wash liquors, and contacted with lime in the waste water treatment circuit to recover zinc as a zinc hydroxide sludge. This sludge is recycled to the gypsum removal and iron removal steps to be used for neutralisation.

Releases

Point sources of releases to air and water are shown on Figures A6.3.1 and A6.3.2 and controlled as outlined above. Further details of control technology are provided below. Selected release data for the period 1988 to 1995 are presented in Table A6.3.1 and Figure A6.3.3 and projected levels for the year 2000 are included. Releases of *CEPA* substances decreased by over 88% from 1988 to 1995 and further release reductions are projected.

Flin Flon Mill

Slurried gangue minerals, or tailings, are pumped from the mill to the Flin Flon tailings impoundment area. Tailings pond drainage, site runoff, and several miscellaneous plant discharges are also pumped to the tailings pond after having been treated with lime.

The Flin Flon tailings impoundment area consists of three ponds in series. The primary and secondary ponds act as clarifiers by allowing the settling of suspended solids. The final, or clarification pond, is used for removal of dissolved metals. Prior to entering the clarification pond, the influent is treated with lime, resulting in metal hydroxide precipitation and subsequent settling. The discharge from the clarification pond is released to the Flin Flon Creek/Ross Lake system.

Copper Smelter

Operation of the copper smelter is based upon pyrometallurgical principles, and as a result produces emissions to the atmosphere. Off gases from the copper roasters pass through an electrostatic precipitator (ESP) prior to discharge via the main 250 metre stack built in the early 1970s. Reverberatory furnace and converter emissions are passed through an ESP and a baghouse before discharge through the main stack. The baghouse has recently been upgraded and now uses state-of-the-art membrane filter technology to remove particulate matter from the gas stream.

Zinc Plant

The zinc plant uses only hydrometallurgical techniques in the production of zinc. This results in no atmospheric emissions. Wastewater discharges are recycled within the plant.

Regulatory and Non-Regulatory Programs

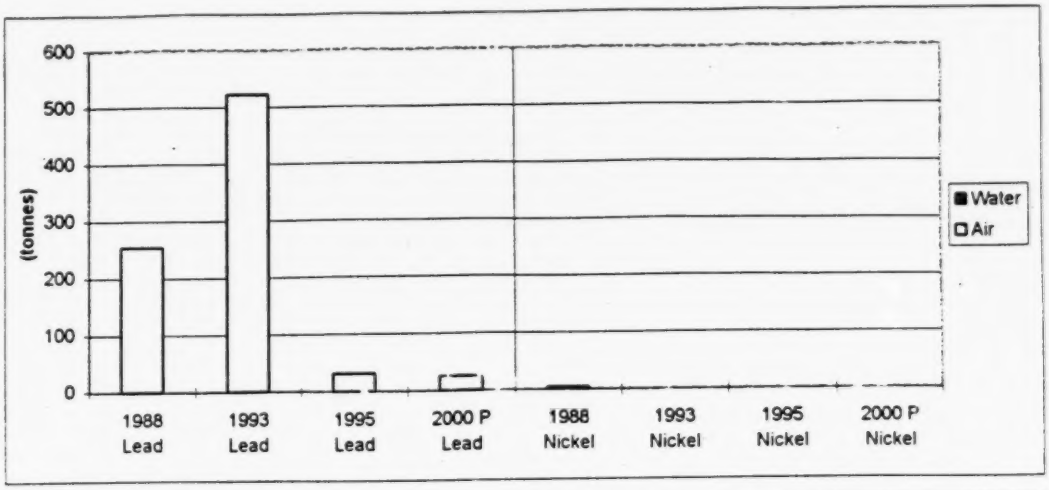
Atmospheric emissions from the copper smelter are regulated by the Manitoba Department of the Environment. SO_2 emission limits of 23 kilotonnes per calendar month and 220 kilotonnes per calendar year were imposed in 1994. Actual emissions of SO_2 were approximately 162 kilotonnes in 1995 and 184 kilotonnes in 1996.

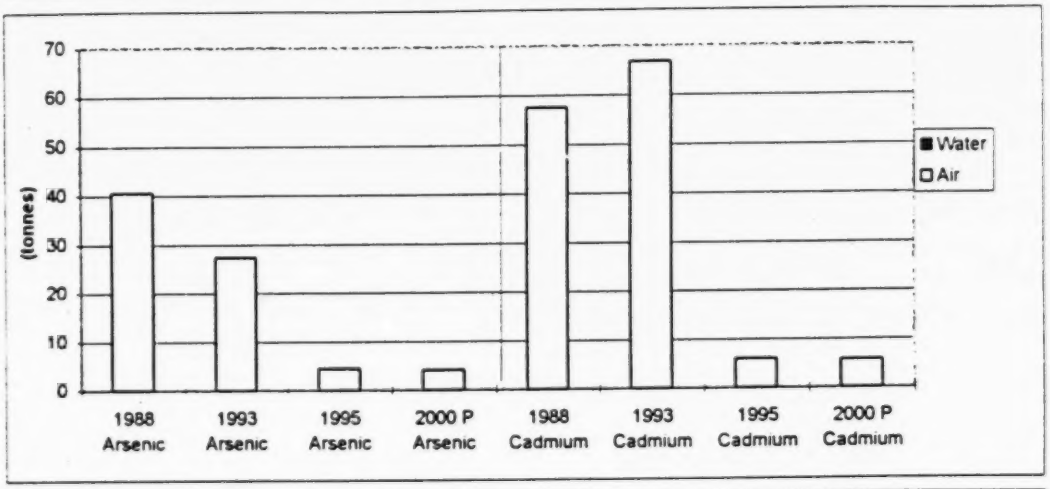
Table A6.3.1 **Releases to Air and Water and Off-site Transfers by Hudson Bay, Flin Flon, Manitoba (tonnes) (Cu-Zn Smelter and Refinery)**

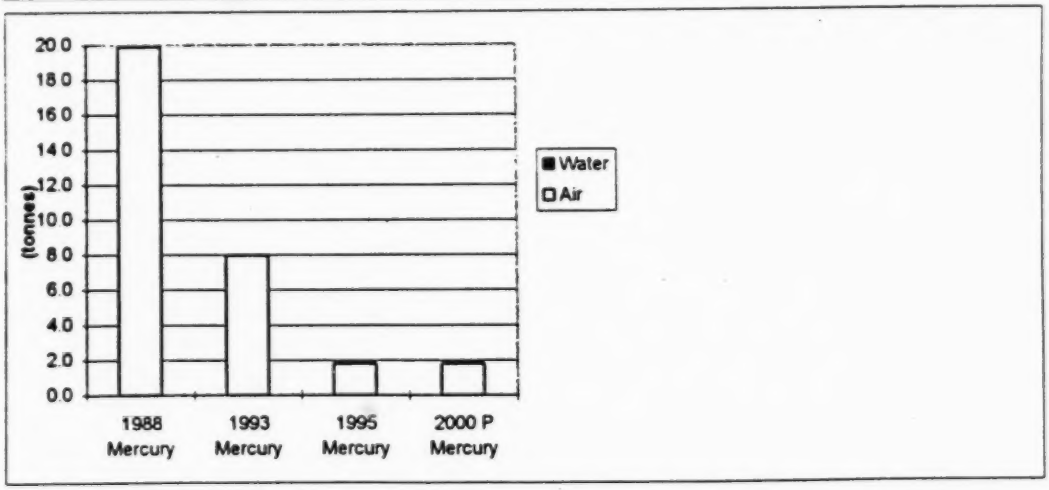
Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	40.6	27.4	4.5	4.1
Water Releases	0.0	0.0	0.0	0.0
Total Releases	40.6	27.4	4.5	4.1
Transfers Off-site				
Cadmium				
Air Releases	57.6	66.8	6.0	5.8
Water Releases				
Total Releases	57.6	66.8	6.0	5.8
Transfers Off-site				
Lead				
Air Releases	254.0	521.6	30.6	25.4
Water Releases	0.0	0.0	0.0	0.0
Total Releases	254.0	521.6	30.6	25.4
Transfers Off-site				
Mercury				
Air Releases	19.90	7.97	1.80	1.80
Water Releases				
Total Releases	19.90	7.97	1.80	1.80
Transfers Off-site				
Nickel				
Air Releases	4.0			
Water Releases				
Total Releases	4.0			
Transfers Off-site				

All water releases from the mine-mill smelter refinery complex are attributed to the mine-mill operations.

Figure A6.3.3 Hudson Bay Mining and Smelting Releases to Air and Water







Particulate emissions from the copper smelter are regulated at 258 tonnes per calendar month and 2500 tonnes per calendar year. Actual particulate emissions were approximately 650 tonnes in 1995 and 1150 tonnes in 1996.

The discharge of liquid effluent from the Flin Flon tailings impoundment area is regulated under a Saskatchewan ministerial order.

In 1994, HBM&S accepted the Accelerated Reduction / Elimination of Toxics (ARET) challenge and submitted an action plan outlining targets for reducing heavy metal emissions by 50-90% from 1988 levels (reduction levels vary by element). In 1995, HBM&S joined the Voluntary Challenge Registry (VCR) and agreed to limit greenhouse gas emissions.

Monitoring

A network of five SO_2 monitoring stations (one operated by the province of Manitoba and four by HBM&S) provide real time ambient air quality data for comparison to provincial guidelines.

A real time continuous emission monitor is located on the main stack and provides data on total particulate emissions. Additionally a network of three high volume air sampling stations (one operated by the province of Manitoba and two by HBM&S) provide data on ambient levels of total and respirable particulate.

Daily and weekly monitoring by HBM&S is conducted at the tailings pond discharge point and up to 10 km downstream.

Programs and Plans

1988 HBM&S commenced a rigorous program of decommissioning and rehabilitating former mine sites. Two mill and ten mine sites have been completed and work is currently under way at one mill and four mine sites.

1989-91 Installation of a five station (one of which is operated by the Manitoba government) SO_2 monitoring system in the Flin Flon/Creighton residential area, directly connected to the smelter control room and allowing real time process responses to incidents of elevated SO_2.

1991 A waste water treatment plant was commissioned at the Trout Lake mine, completing a program to provide treatment facilities at all operations and which included complete civil restructuring of the Flin Flon tailings pond. During the 1990-96 period, compliance with *Fisheries Act* guidelines and regulation limits was 99.6%.

1991-93 Design, construction, and implementation of a two-stage zinc pressure leach facility. Replacement of the former roast-leach-electrowinning facility effectively eliminated all liquid and atmospheric emissions from this portion of the Flin Flon complex, and reduced carbon dioxide emissions from the complex by nearly 50%.

1994-96 Installation of a three site (one of which is operated by the Manitoba government) high volume particulate monitoring system. Initially developed to monitor ambient levels of total suspended particulate, the system was upgraded in 1996 to include PM_{10} monitoring for respirable particulate material.

1994-97 Upgrade of the copper smelter baghouse. Synthetic membrane filter bags were installed to replace the fibreglass filters originally used in the facility. The new bags proved so successful that problems were encountered in removing the large quantity of particulate matter captured. To assist in the removal of dust, a system of cleaning the bags using sonic vibrations was developed and installation began in late 1996.

1996 Environmental Liaison Committee established, involving representatives of Manitoba and Saskatchewan governments, local communities, unions, and environmental groups. The mandate of the committee is to provide direction to HBM&S in environmental programs including priority setting.

The total capital cost of the above projects was nearly $250 million.

1997-2000 Work to improve the separation of minerals during milling and concentrating should decrease the quantity of cadmium and mercury entering the copper smelter, and thereby avoiding a potential emission.

Improvements in the cadmium production circuit are expected to reduce cadmium emissions by 75%.

Issues

The zinc operation employs state-of-the-art technology. No practicable upgrade technology is available for the Smelter. Process spill gas is an air quality issue; HBMS has committed to reducing spill gas incidents by 90% from 1995 levels by the year 2000.

Technical Options To Achieve Further Release Reductions

As active program continues to review technology available to further reduce emissions.

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6.4 INCO LIMITED THOMPSON DIVISION THOMPSON, MANITOBA

Profile

The Inco operation at Thompson Manitoba is an integrated mining, milling, smelting and refining operation. It was officially opened in 1961. This operation processes ore to produce primarily nickel with cobalt as a byproduct.

Smelter

Nickel concentrate from the milling stage is roasted in fluid bed roasters for sulphur removal. Flux (sand) for the smelting stage is added to roasters for preheating. The calcine from the roasters is fed to electric furnaces for smelting where it separates into slag (oxide) and matte (sulphide) phases. The slag is skimmed, granulated in water and pumped to the slag storage area. The matte from the electric furnaces is transported to the Peirce-Smith converters by ladle and further oxidized for iron and sulphur removal. The slag from the converting stage is returned to the electric furnaces for metal recovery. The finished matte from the converters is cast as anodes for further processing in the Refinery. Sec Figure A6.4 1.

Refinery

The matte anodes from the Smelter are transported to the Refinery for electrorefining to nickel cathodes, Inco S-Rounds and R-Rounds suitable for market. Byproduct residue is sent to the Inco Port Colborne Refinery for cobalt and precious metal recovery. See Figure A6.4.2.

Releases:

Releases are detailed in Table A6.4.1 and in Figure A6.4.3.

The offgases from the fluid bed roasters are treated for particulate removal in cyclones and electrostatic precipitators. The electric furnace offgases and the offgases from the converting stage are treated in electrostatic precipitators for particulate removal and then vented to atmosphere.

Excess water is treated with lime for metal precipitation, as required for metal precipitation, prior to release into the environment.

Figure A6.4.1 Inco Thompson Nickel Smelter Process Flow Sheet

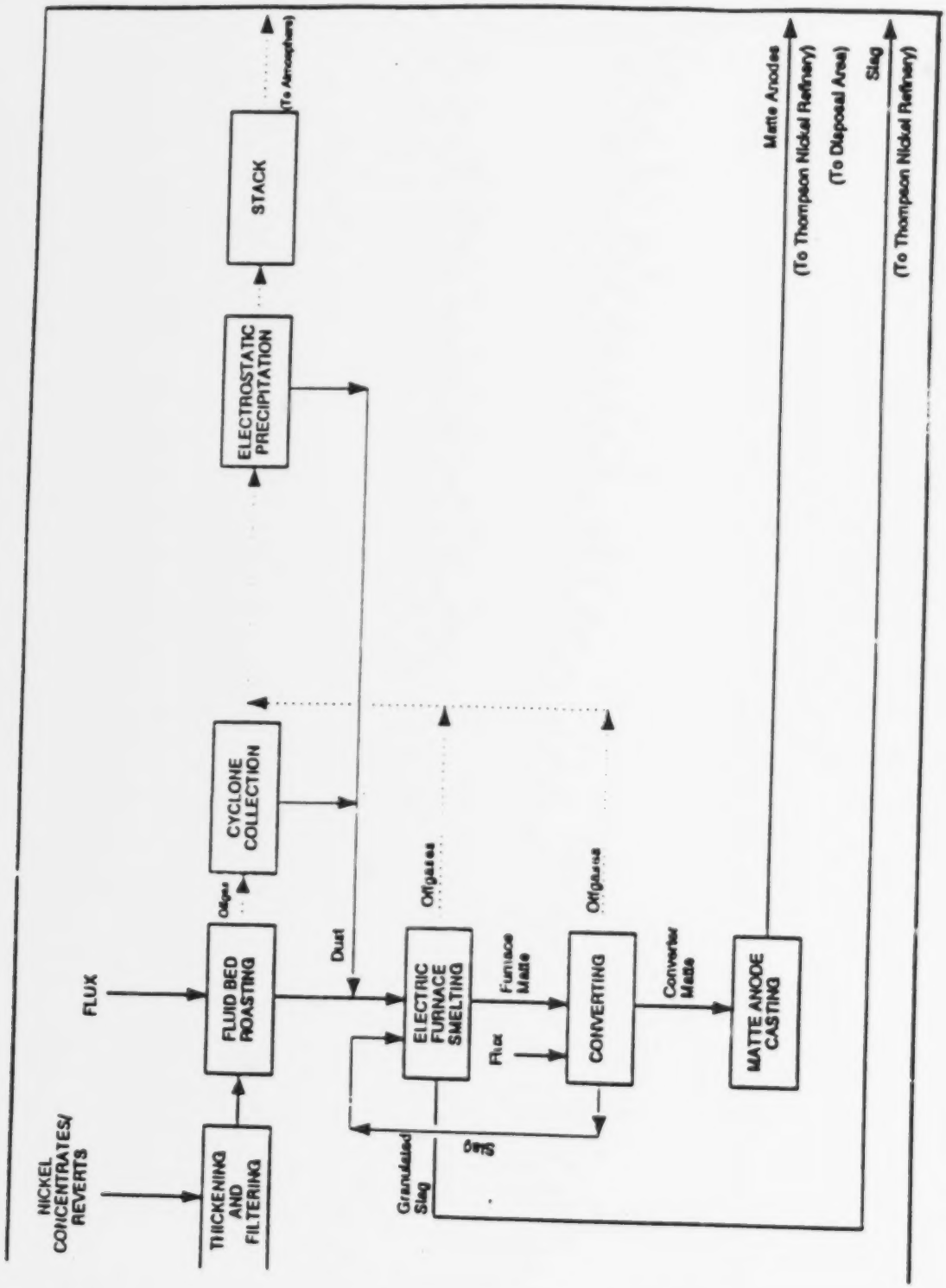


Figure A6.4.2 Inco Thompson Nickel Refinery Process Flow Sheet

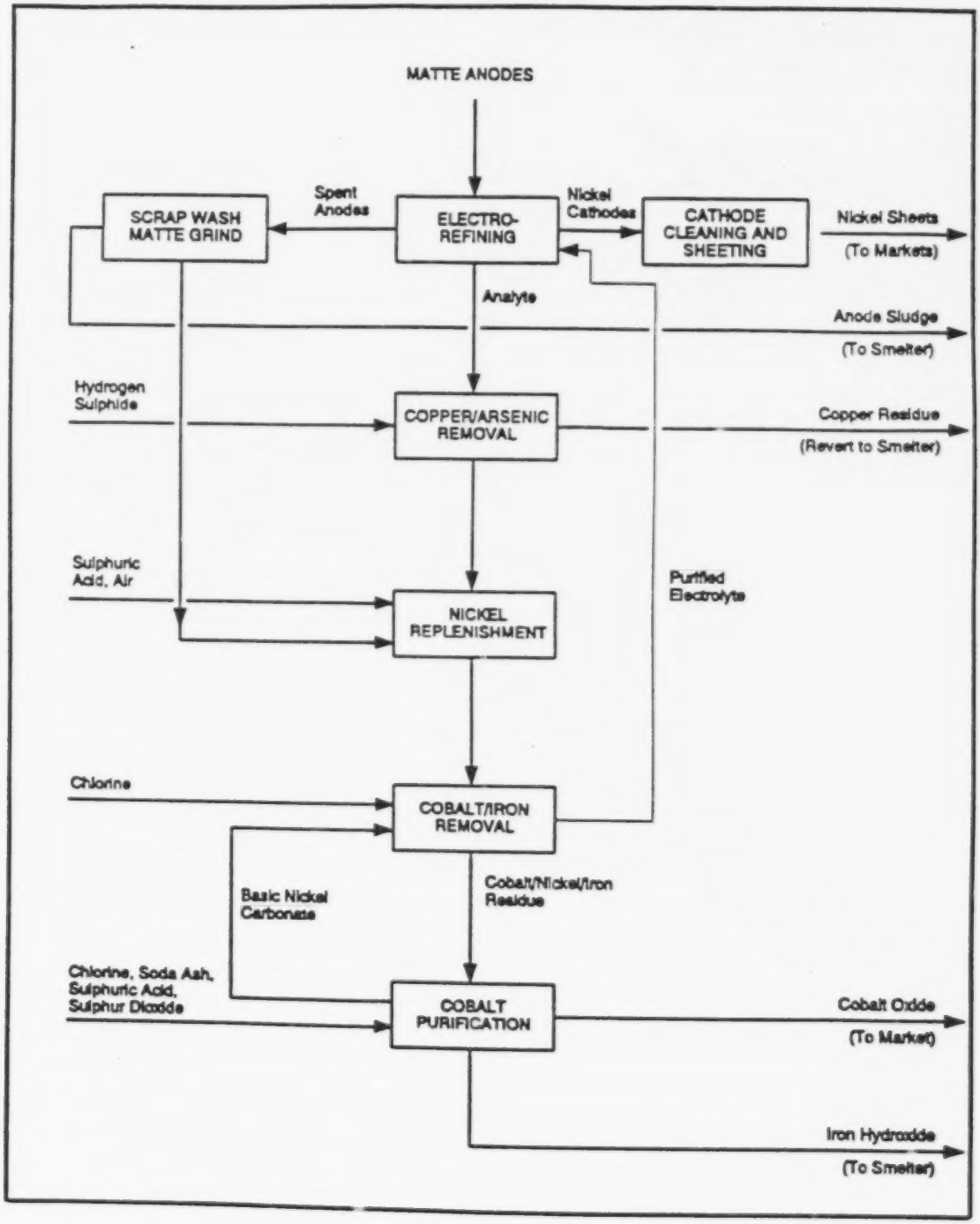
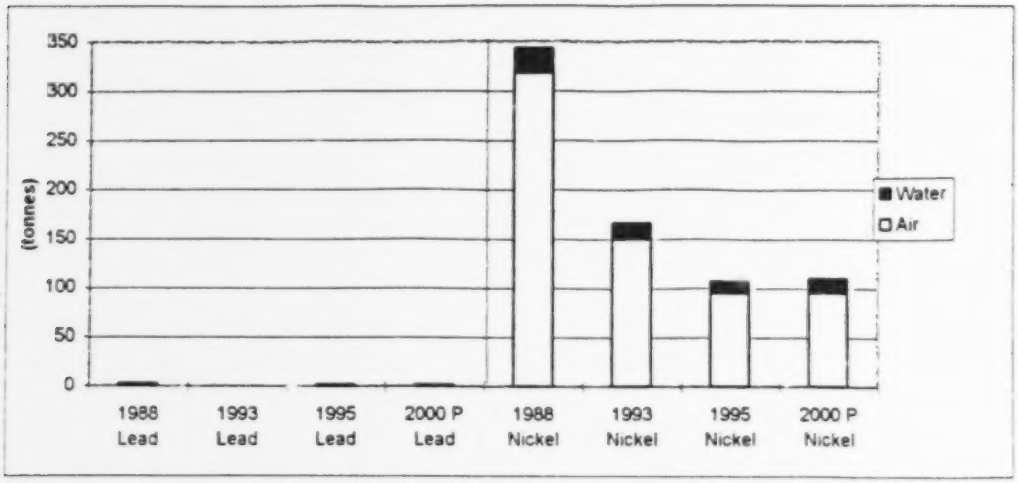


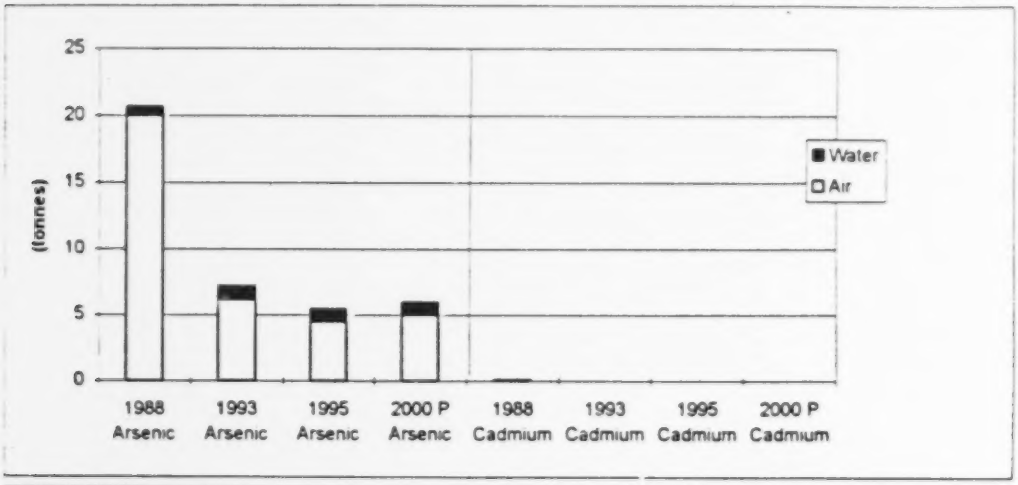
Table A6 4.1 **Releases to Air and Water and Off-site Transfers by Inco, Thompson, Manitoba (tonnes) (Ni-Cu Smelter and Refinery)**

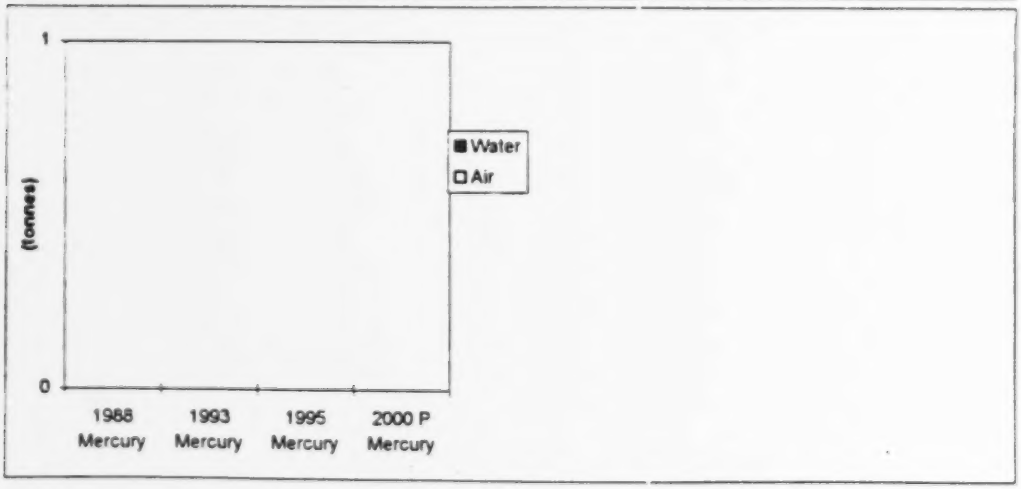
Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	20.0	6.2	4.5	5.0
Water Releases	0.7	1.0	1.0	1.0
Total Releases	20.7	7.2	5.5	6.0
Transfers Off-site		0.0		
Cadmium				
Air Releases	0.1			
Water Releases	0.0			
Total Releases	0.1			
Transfers Off-site				
Lead				
Air Releases	2.0		2.0	2.0
Water Releases	1.2			
Total Releases	3.2		2.0	2.0
Transfers Off-site				
Mercury				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Nickel				
Air Releases	318.0	149.8	94.7	95.0
Water Releases	25.5	16.6	12.1	15.0
Total Releases	343.5	166.5	106.8	110.0
Transfers Off-site		0.0		

Note: Smelter and refinery effluent (exept slag drainage) goes to the tailings pond with mine/mill effluent. About 60-70% of metals in final effluent(water release) is attributed to mine/mill facilities and about 30-40% is attributed to the refinery and Smelter.

Figure A6.4.3 Inco Thompson, Releases to Air and Water







Regulatory and Non-Regulatory Programs

Environmental aspects of Incos operations in Thompson are regulated by the Manitoba Department of the Environment. These regulations include a site specific sulphur dioxide emission cap as well as a limit on total particulate. A Site Permit governs the total emission sources.

Monitoring and Research

Air emissions are measured and reported on a ongoing basis. Sulphur dioxide emission reductions have been the focus in the past with the reductions achieved by rejecting sulphur bearing pyrrhotite.

Water discharges are measured and data reported on an ongoing basis.

Programs and Plans

1988-1995	Reduction in sulphur dioxide emissions achieved through rejection of pyrrhotite prior to the smelting process.
1995-Present	Study of alternatives for reduction of particulate emissions.

Issues

The Base Metal Smelting Sector represents plants with unique processes, different metallurgy and varying feedstocks. Although some control technologies are applicable in general use for the most part the solutions are not directly transferable to other facilities. Past reductions in emissions have required research into basic processes, new control technologies and better materials of construction. Further reductions will require development of effective and economical methods to control emissions with consideration of their impact on the process and the ability to compete in the metal markets.

The Thompson operation of Inco is in a remote area with high transportation costs. this presents increased economic challenges when trying to apply some emission reduction technologies such as acid production.

Any work planned for the future must anticipate the impact of other initiatives such as the Acidifying Emissions Taskforce as well as the current review of particulate size considerations. These initiatives can change the selection of technologies for emission reduction.

Technical Options to Achieve Further Release Reductions

The facility is reviewing options for reduction of particulate emissions. One technique would involve upgrading of the electrostatic precipitator. Another method would involve changes to the process gas transport system from the roasters which would include installation of fans and a cyclone to reduce particulate loadings prior to processing the gases through the electrostatic precipitator.

The review will determine the technical and economic feasibility of the control equipment under study.

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6.5 FALCONBRIDGE LIMITED KIDD METALLURGICAL DIVISION TIMMINS, ONTARIO

Profile

Falconbridge Limited's Kidd Metallurgical Division, located in Timmins, Ontario is an integrated, multi-plant facility for the mineral processing of base metal ores and the metallurgical processing and refining of metals. The facility produces copper, zinc, cadmium and indium, as well as several by-products such as sulphuric acid and liquid sulphur dioxide. The main source of feed is ore from the Kidd Mine located 27 kilometres northeast of the metallurgical site and is augmented by a variety of purchased primary and secondary feed materials. Selected production data for the period 1988 to 1996 are presented in Table A6.5.1, which includes projected levels for the year 2000.

Table A6.5.1 Production Summary (tonnes)

Products	1988	1993	1996	2000 (Projected)
Cathode copper	90,700	97,206	99,109	140,400
Refined zinc	124,800	139,100	131,078	146,090
Cadmium	546	805	798	1,180
Indium (Troy oz)	N/A	700,880	729,030	659,000
Sulphuric acid	581,000	613,890	618,435	579,100
Liquid sulphur dioxide	N/A	11,400	25,141	30,940

Process Description

Concentrator

The Kidd Concentrator began operation in November 1966. In the concentrating process, the ore first goes through secondary and tertiary crushing, where it is reduced to a diameter of approximately 13 mm. This is followed by grinding which reduces the ore to a fine slurry. The slurry is then fed into flotation tanks and chemical reagents are used to render the metal-containing minerals hydrophobic, which allows them to be floated to the surface in a froth and skimmed off. The collected froth is then dewatered (thickened, filtered) and dried using natural gas to produce a mineral concentrate suitable for metallurgical processing.

Figure A6.5.1 Falconbridge Kidd Copper Smelter Process Flow Sheet

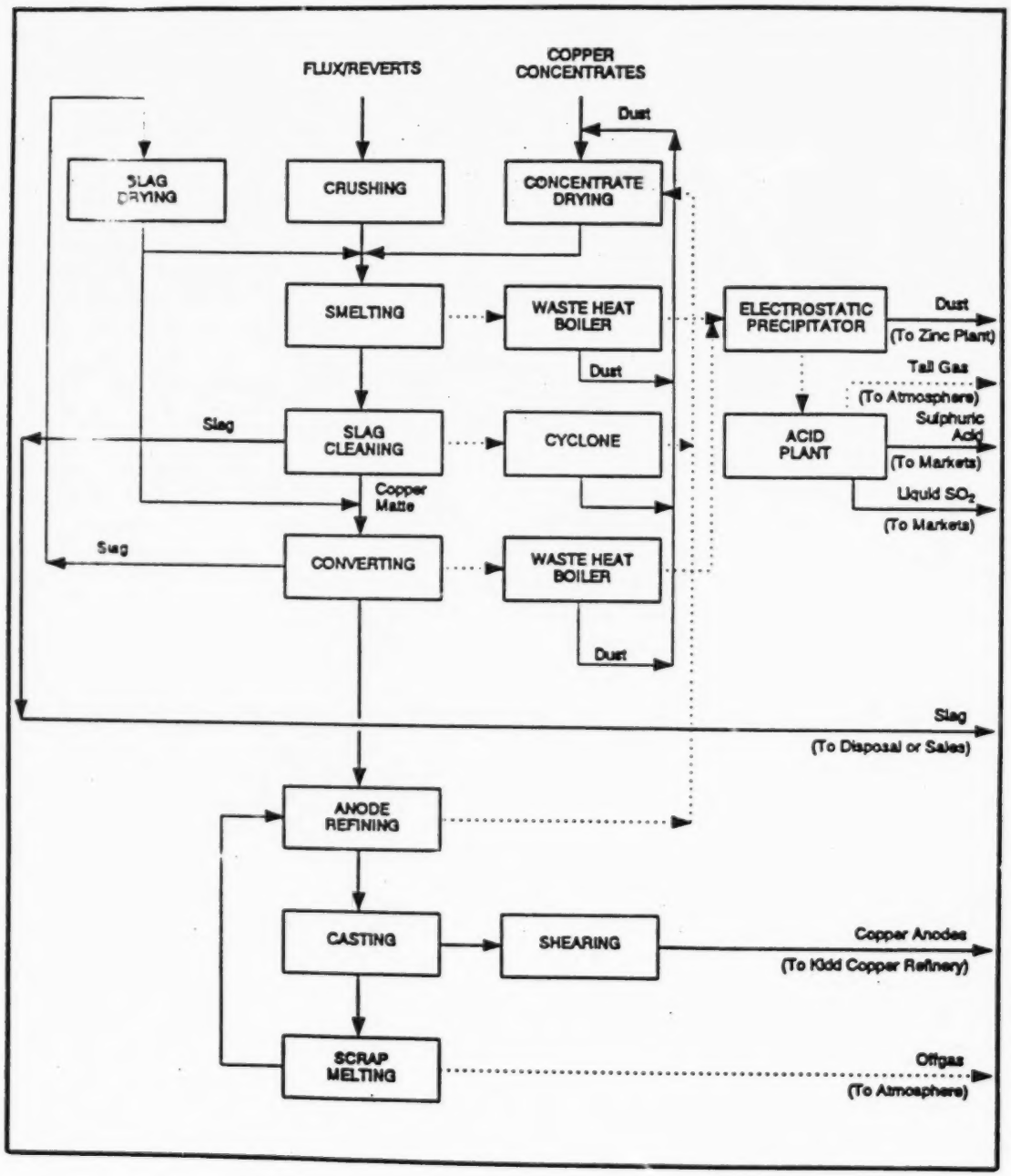


Figure A6.5.2 Falconbridge Kidd Copper Refinery Process Flow Sheet

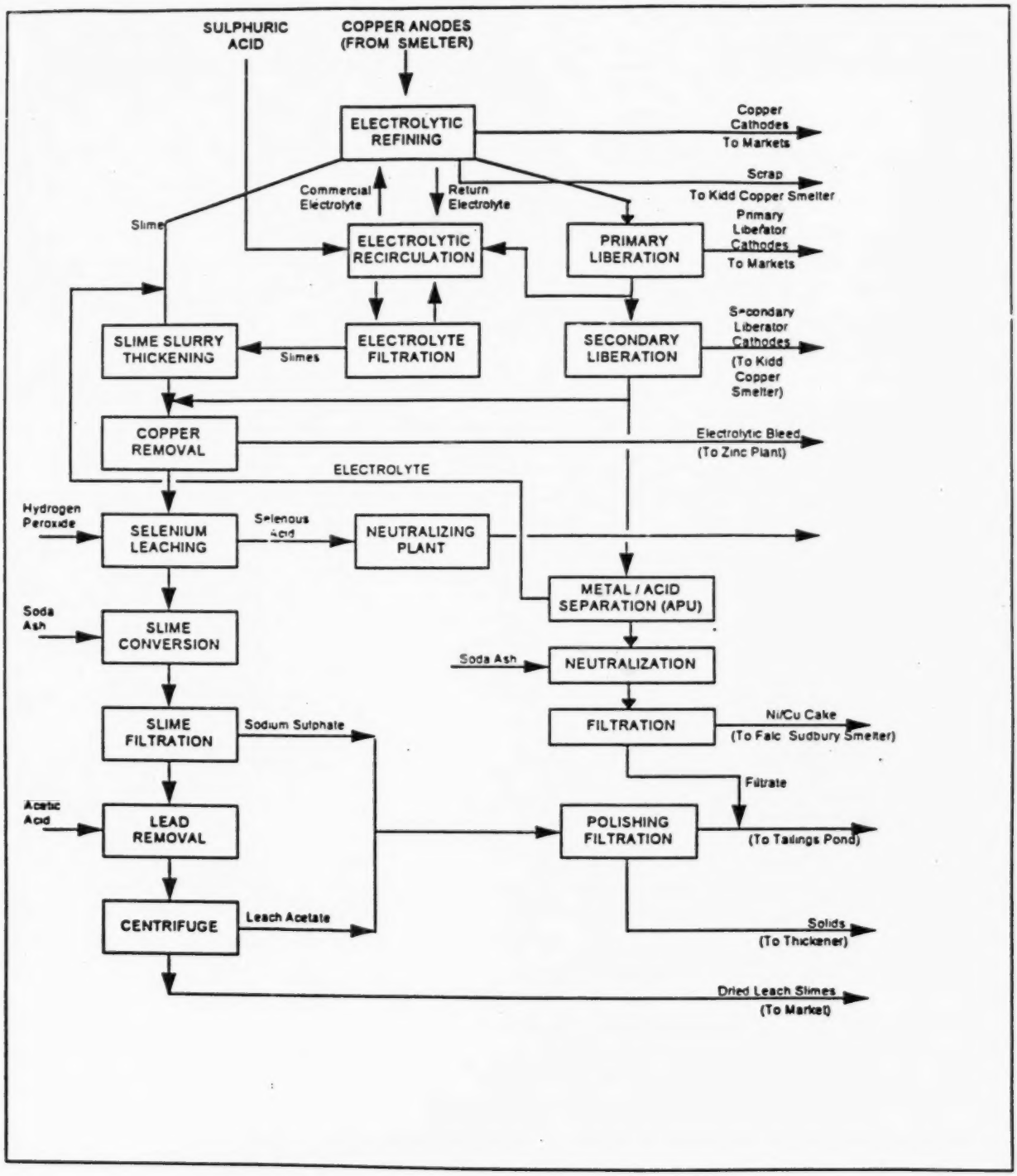
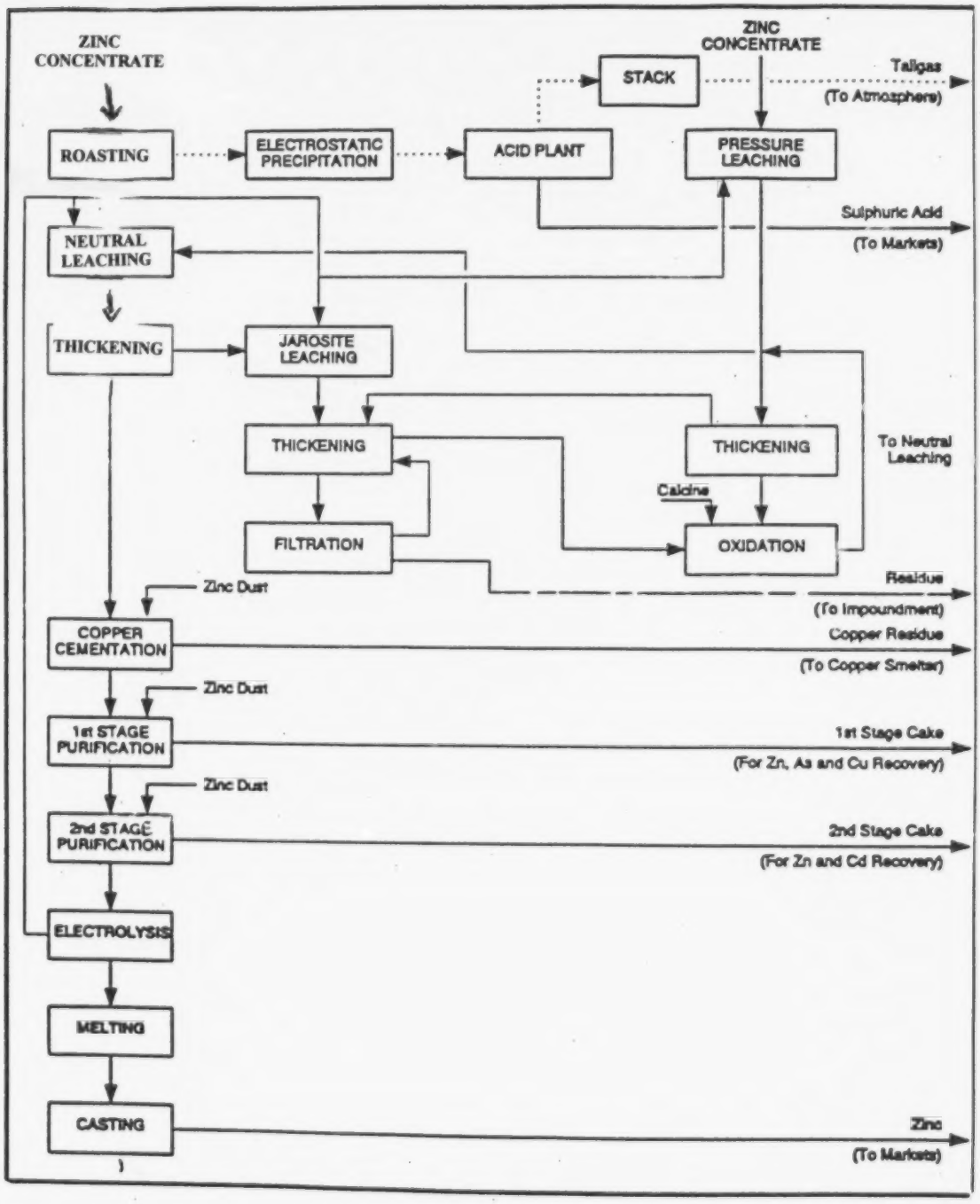


Figure A6.5.3 Falconbridge Kidd Zinc Plant Process Flow Sheet



Zinc Operations

The Zinc Plant began operation in 1972 and is based on standard electrolytic zinc plant technology. Zinc concentrates are first roasted in two standard Lurgi turbulent bed roasters to remove the sulphur and produce a calcine (primarily zinc oxide). The sulphur in the concentrate is converted to sulphur dioxide (SO_2) and collected in the off-gas. The off-gas is cleaned, dried and sent to the Roaster Acid Plant where it is converted to sulphuric acid (H_2SO_4). The Acid Plant is a Monsanto single-absorption plant with a design conversion efficiency of approximately 98%.

After the roasting process, the calcine is leached with sulphuric acid to dissolve the zinc and the resultant zinc sulphate solution is further treated to remove impurities. Iron, which is co-extracted with the zinc, is precipitated as sodium jarosite and sent to tailings for disposal. Recovery, purification, melting and casting of cadmium metal also takes place in the Zinc Leach Plant.

The zinc sulphate solution (neutral solution) is then cooled and pumped to storage tanks, from which it is fed continuously to the circulating electrolyte in the Electrolytic Cellhouse. In the electrowinning process, direct current is applied, forcing the zinc to deposit onto aluminum cathodes. The cathodes are then removed from the cells and the zinc is stripped off .

The zinc sheets are then melted in one of two induction furnaces and cast into either 25 kg slabs or jumbos weighing in excess of one tonne.

In 1983/84 a pressure leach system was installed to increase the capacity of the Zinc Plant. This system utilizes oxygen and high temperature in an autoclave to directly produce zinc sulphate from the zinc concentrate, thus eliminating the need for roasting. Approximately 20% of the zinc concentrate is processed using this system.

Copper Operations

The Copper Smelter and Refinery were commissioned in 1981. The smelter is divided into four process areas; feed preparation, continuous smelter, melting and casting, and auxiliaries.

In the feed preparation area, the various feed materials (copper concentrate, silica flux, limestone, recycle slag, revert material, secondary feeds) are dried and stored. Off-gases from the anode furnaces are used as a source of heat for drying the feed materials.

The continuous smelter is based on the Mitsubishi process and consists of three furnaces (smelting furnace, cleaning furnace, converting furnace), interconnected by gravity flow launders. Blended feed is pneumatically conveyed to the smelting furnace

through feed pipes which are sheathed in process lances through which oxygen-enriched air is blown, resulting in a smelting reaction which is almost autogenous. The matte and slag overflow continuously down a launder to the slag cleaning furnace, where the matte and slag separate. The slag overflows to a granulation system and is discarded. The matte is siphoned out of the furnace and flows to the converting furnace where it is oxidized to blister copper. The blister copper is then siphoned out of the furnace and directed into a holding furnace, from which it is periodically transferred to the anode furnaces by ladle. The off-gas from the smelting and converting furnaces passes through waste heat boilers (heat recovery for steam generation), is cleaned (electrostatic precipitators and scrubbers), dried and sent to the Smelter Acid Plant where it is converted to sulphuric acid (H SO). The Acid Plant is a double-contact, double-absorption plant with a design conversion efficiency of 99.5%. Approximately 10% of the sulphur dioxide contained in the off-gas stream is recovered as liquid sulphur dioxide.

Following oxidation and reduction in the anode furnaces, the copper is poured from the furnace to a Hazelett casting machine which produces a continuous strip of solid copper. Anodes are then pressed from the strip and transported to the Copper Refinery.

At the refinery, the copper anodes are submerged, along with stainless steel cathodes, in an electrolyte solution. An electric current is applied which causes the anodes to dissolve and copper is plated onto the stainless steel cathode, from which it is later stripped off.

Indium Plant

The Indium Plant/Dust Treatment Plant, which is formally associated the Zinc Operations, was commissioned in late 1990. The Plant processes electrostatic precipitator dust from the Copper Smelter to produce a copper residue, a lead/silver residue, and a zinc solution. Indium is separated by solvent extraction, recovered by cementation, refined by electrolysis, and cast into bars.

Releases

The design of the Kidd pyrometallurgical processes allows for the capture of nearly all of the sulphur dioxide generated by the processes for conversion to sulphuric acid or liquid sulphur dioxide. The total sulphur dioxide released to atmosphere from the site in 1996 was about 5,600 tonnes. This represents an emission rate of 24 kilograms of sulphur dioxide released per tonne of refined metal produced.

The direct emission of particulate contaminants from the pyrometallurgical processes is virtually eliminated due to the fact that the process off-gas streams undergo several stages of cleaning prior to going to the acid plants. As a result, the major sources of particulate emissions to air result from activities which are ancillary to the main

processes (i.e. drying, conveying, etc.), and are thus comparatively small to begin with. In most of these cases some form of air cleaning device, such as scrubbers, cyclones or baghouses are used to remove particulates from the air prior to discharge. Additional sources of particulate emission to air are fugitive emissions from buildings and surface stockpiles.

All liquid effluents from the Kidd metallurgical processes undergo treatment in a 1,250 hectare tailings treatment/disposal facility prior to being discharged into the natural environment. Some streams, such as the weak acid from the off-gas scrubbers, are pretreated (neutralized) prior to being pumped to tailings. Additionally, some streams are recycled internally, thus reducing the load to the treatment system. Examples include slag granulation water, which is used for mineral flotation in the Concentrator, and copper sulphate solution from the Copper Refinery, which is used as a reagent in the Concentrator.

Selected release data for the period 1988 to 1995 are presented in Table A6.5.2 and Figure A6.5.4 projected levels for the year 2000 are included. Releases of *CEPA* substances decreased by over 13% from 1988 to 1995 and further release reductions are projected.

Regulatory and non Regulatory Programs

The Kidd Metallurgical operations are impacted to varying degrees by a variety of federal and provincial environmental statutes, regulations and operating guidelines, many of which address releases to land, air or water. In addition, the Kidd Metallurgical Division has a total of 88 Environmental Certificates of Approval. Of these, 78 pertain to air, 8 to sewage and 2 to waste. Some of these Certificates of Approval specify emission limits and/or operating and maintenance criteria.

Monitoring and Research

The facility operates continuous emission monitors for seven point sources of sulphur dioxide and continuously monitors ambient ground level concentrations of sulphur dioxide at four stations. High volume air sampling over a period of 24 hours is conducted on a six day cycle at three stations for determining ground level particulate concentrations. Continuos passive monitoring for dustfall and wet sulphate deposition is conducted at 10 locations.

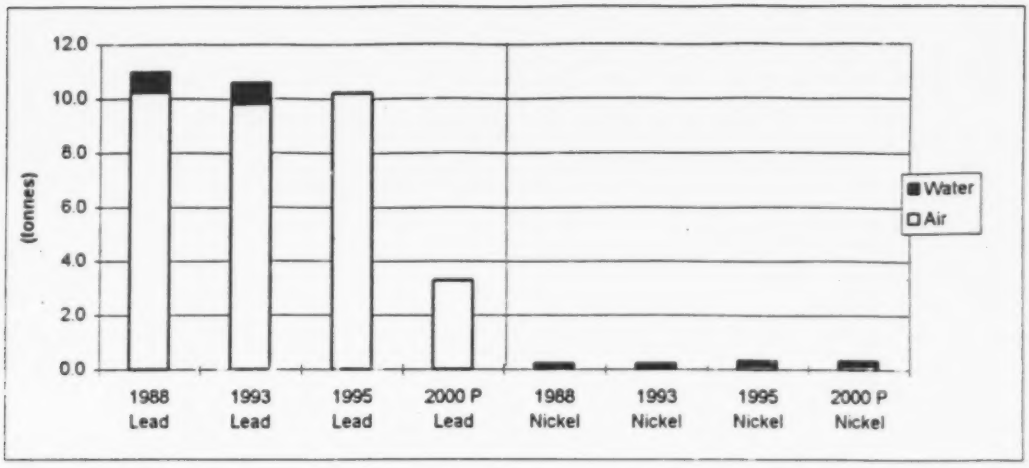
Liquid effluent monitoring is conducted in accordance with Ontario's MISA requirements, including periodic effluent characterization, routine chemical analysis and regular effluent toxicity testing.

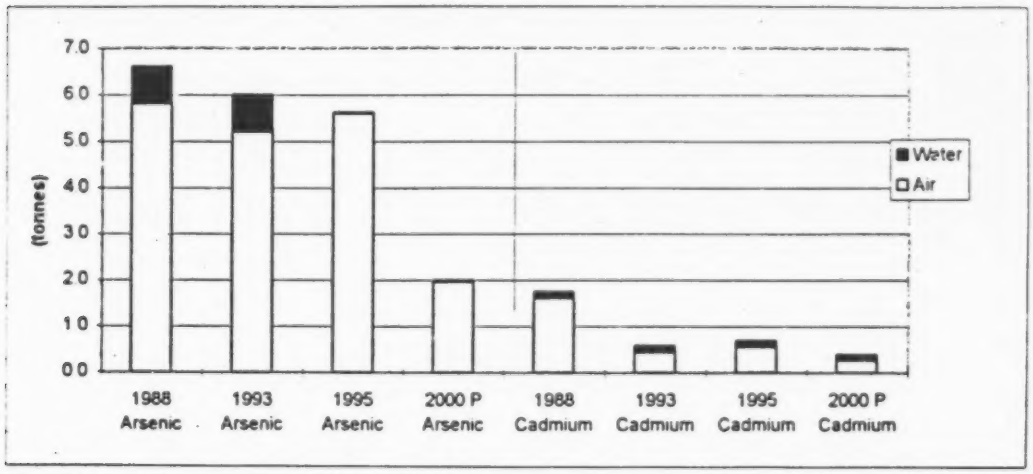
Table A6.5.2 **Releases to Air and Water and Off-site Transfers by Falconbridge Kidd, Timmins, Ontario (tonnes) (Cu Smelter and Refinery and Zinc Plant)**

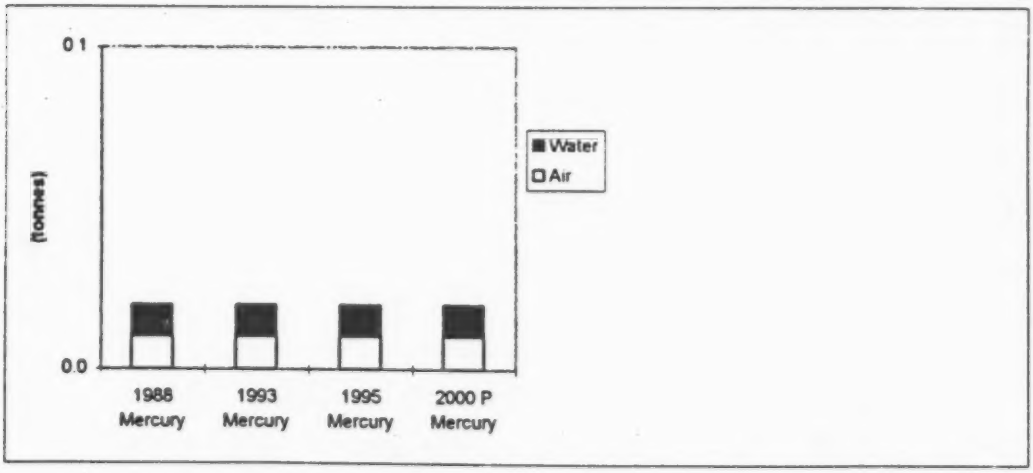
Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	5.8	5.2	5.6	2.0
Water Releases	0.8	0.8	0.0	0.0
Total Releases	6.6	6.0	5.6	2.0
Transfers Off-site		0.0	0.0	
Cadmium				
Air Releases	1.6	0.4	0.6	0.3
Water Releases	0.2	0.2	0.1	0.1
Total Releases	1.8	0.6	0.7	0.4
Transfers Off-site		0.0	0.0	
Lead				
Air Releases	10.2	9.8	10.2	3.3
Water Releases	0.8	0.8	0.0	0.0
Total Releases	11.0	10.6	10.2	3.3
Transfers Off-site		0.0	0.0	
Mercury				
Air Releases	0.01	0.01	0.01	0.01
Water Releases	0.01	0.01	0.01	0.01
Total Releases	0.02	0.02	0.02	0.02
Transfers Off-site				
Nickel				
Air Releases	0.0	0.0	0.1	0.1
Water Releases	0.2	0.2	0.2	0.2
Total Releases	0.2	0.2	0.3	0.3
Transfers Off-site			0.0	

Smelter and refinery effluents are combined with tailings effluent and are treated in tailings pond. Any metals in tailings effluent are primarily attributable to milling operations.

Figure A6.5.4 Falconbridge Kidd, Releases to Air and Water







Programs and Plans

1993/4	Improvements to the feed preparation dryer baghouse improved capture efficiency and reduced particulate emissions.
1996	Extensive modifications to effluent polishing ponds increased retention time and improved settling of precipitates. This, along with the introduction of early lime addition at the thickener overflow, decreased metal concentrations in the final effluent by 50%.
1997	Design and installation of a new Smelter boiler dust handling system to improve working conditions in the plant and consequently reduce fugitive emissions to air.
1997-2000	Reduction in stockpile inventories and improved secondary feed material handling to reduce fugitive emissions from the site.
	Procedures and equipment changes will be made to allow for reintroduction of spent copper anodes into the converting furnace. This will greatly reduce the operating time of the Asarco shaft furnace, which is a major contributor to the site's total particulate releases.

Issues

The Kidd facilities have strong emission control systems in place and as a result have relatively few environmental issues.

One of the current priorities is the completion of a closure plan for the tailings pond area at the metallurgical site. The Ontario requires these closure plans which are, in large part, comprehensive environmental assessments of the various operations in terms of the current and future potential environmental liabilities. In addition, the plans provide action items to address potential long term environmental issues. The Kidd Metallurgical Division has been involved in a number of research projects, spanning several years, in a number of technical disciplines including geochemistry, hydrology, hydrogeology, geology, environmental chemistry and biology. Reviews of the "state of the art" technologies relating to mining environmental issues have also been performed.

The cumulative result of this work is the closure plan, or decommissioning strategy, for the facility which is due to be submitted to the Ontario government by October 31, 1997.

Beyond the submission of the closure plan, research will continue into new and improved technologies to deal with potential mining and processing environmental issues, as this remains a high priority for the organization.

Technical Options To Achieve Further Release Reductions

During 1997 and 1998, the Kidd Metallurgical Division will undertake a program to better identify and quantify the major point source releases to air. Following this, an environmental engineering firm will be contracted to evaluate the data and recommend the most appropriate and economically-achievable control strategies.

6.6 FALCONBRIDGE LIMITED SUDBURY DIVISION FALCONBRIDGE, ONTARIO

Profile

Falconbridge Limited, Sudbury Division operates a nickel-copper smelter at Falconbridge, Ontario. The plant commenced production in 1930 to process nickel-copper concentrates produced by an associated mine-mill complex. An acid plant entered service in 1978. The smelter now processes copper-nickel concentrates from Falconbridge's Strathcona concentrator and a variety of purchased secondary nickel-cobalt materials. The smelter produces nickel-copper matte and sulphuric acid. Selected production data for the period 1988 to 1995 are presented in Table A6.6.1. Year 2000 production of nickel is expected to be approximately 50% greater than current levels as a result of production from the Raglan project.

Table A6.6.1 Production Summary (tonnes)

Products	1988	1993	1995
Nickel-copper matte	65,394	86,116	75,267
Sulphuric acid	274,129	249,540	212,794

Process Description

The process is outlined in Figure A6.6.1. Nickel-copper concentrate is received from the Strathcona concentrator as a slurry and must be repulped to a consistent density prior to processing in the fluidized bed roasters. Most of the nickel, copper, iron and sulphur in the smelter feed is contained in sulphide minerals. Silica is proportioned to form a low viscosity $FeO\text{-}CaO\text{-}SiO_2$ slag with low nickel and copper content. The roasters oxidize part of the iron and approximately 60% of the sulphide sulphur. Roaster off-gases are treated by a cyclone and electrostatic precipitator to remove dust and fume containing metals. The cleaned gases are treated by a single absorption sulphuric acid plant to remove sulphur dioxide before being released to the atmosphere. Weak acid from the gas cleaning section of the acid plant is neutralized with lime.

The solid product from the roasters is charged to an electric furnace for smelting together with custom concentrate and coke. The non-ferrous gangue minerals, fluxes and iron oxides separate to form a molten oxide slag over the molten nickel-copper-iron sulphide matte phase. Electric furnace slag is granulated and pumped to the slag disposal area where the water is drained and recycled. Off-gases from the electric furnace are treated by cyclones and an electrostatic precipitator for removal of dusts containing metals before being released to the atmosphere. All dusts recovered from electric furnace off-gases are returned to the electric furnace.

Electric furnace matte is transferred to conventional Pierce-Smith converters, where iron and sulphide sulphur are further oxidized to iron oxide and sulphur dioxide. Iron oxide and fluxes combine to form a molten oxide slag over the molten nickel-copper matte, which also contains cobalt and some iron. The higher density matte separates from the converter slag and is cast, crushed, packaged and shipped to Falconbridge's Nikkelverk refinery in Norway. Converter slag contains economic concentrations of metals and is cleaned prior to disposal. Off-gases from the electric furnace are treated by cyclones and an electrostatic precipitator for removal of dusts containing metals before being released to the atmosphere. All dusts recovered from converter off-gases are returned to the electric furnace.

Releases

Point sources of releases to air and water from the smelter are shown on Figure A6.6.1 and controlled as outlined above.

Process gases from the fluidized bed roasters are treated by cyclones and an electrostatic precipitator for particulate control and by a single absorption sulphuric acid plant. Process gases from the reactor are treated by a single absorption acid plant, which recovers approximately 58% of the sulphur input to the smelter. Process gases from the electric furnace and Pierce-Smith converters are treated by cyclones and electrostatic precipitators for particulate control and, combined with the acid plant emissions, account for approximately 27% of the sulphur dioxide are not strong enough or consistent enough in strength to be sent to an acid plant and are released to the atmosphere. The balance of the sulphur input to the smelter is largely distributed to the nickel-copper sulphide matte product, which contains approximately 23% S, with minor amounts also being fixed in slags.

Liquid effluent discharges are minimized by reusing water for slag granulation. Weak acid from the gas cleaning section of the acid plant is neutralized along with other effluents at a lime treatment plant. All process effluents from the smelter are collected, treated and monitored.

Selected release data for the period 1988 to 1995 are presented in Table A6.6.2 and Figure A6.6.2.

Regulatory And Non-Regulatory Programs

The nickel-copper smelter is regulated by the government of Ontario. The Ontario control order limits releases of sulphur dioxide to 100,000 tonnes/year and the actual releases are well below this limit. In 1996 emissions were 54,000 tonnes.

The smelter air permit specifies a point of impingement arsenic standard of 1 $\mu g/m^3$ (½ hour average).

Figure A6.6.1 Falconbridge Sudbury Nickel/Copper Smelter Process Flow Sheet

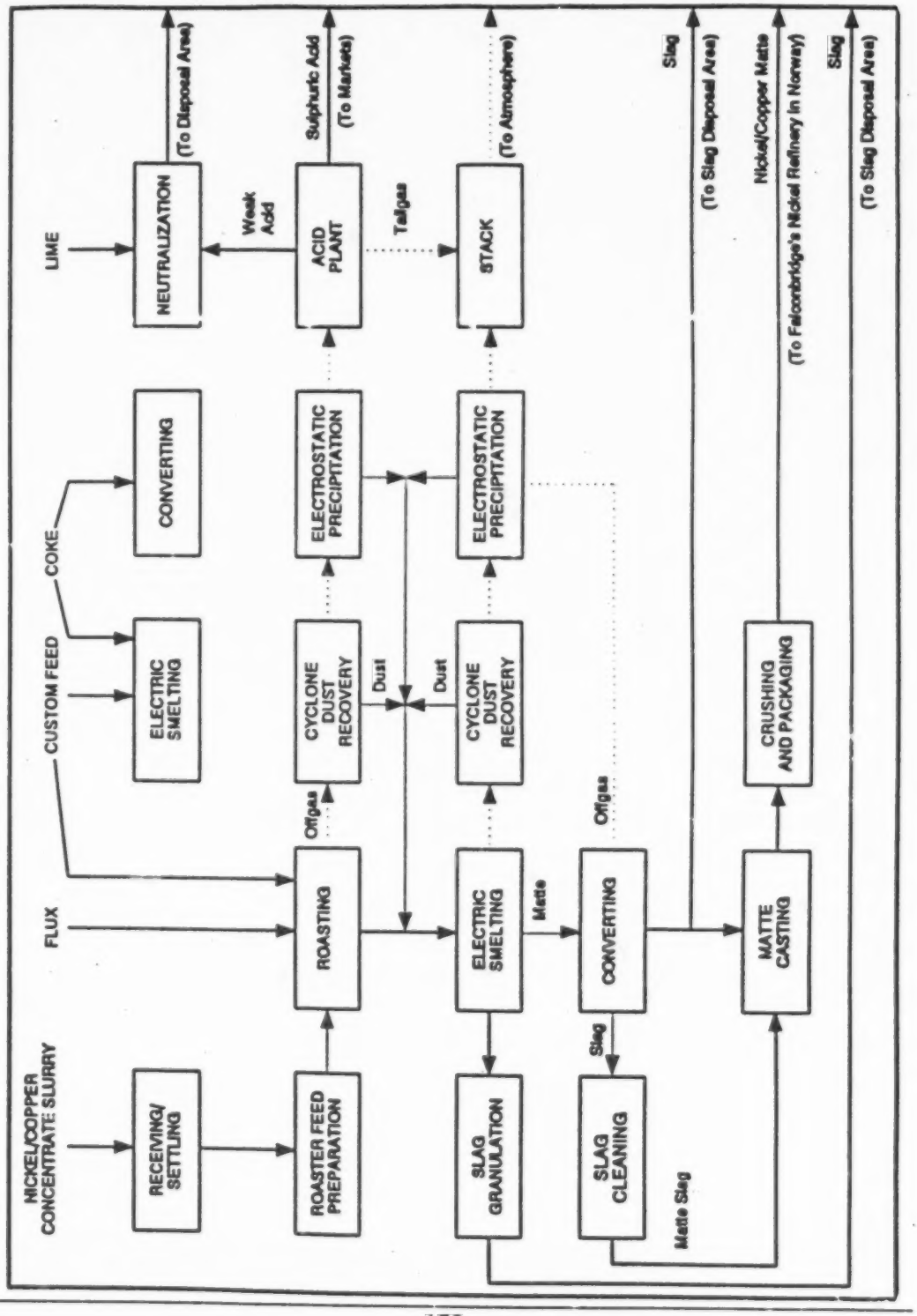
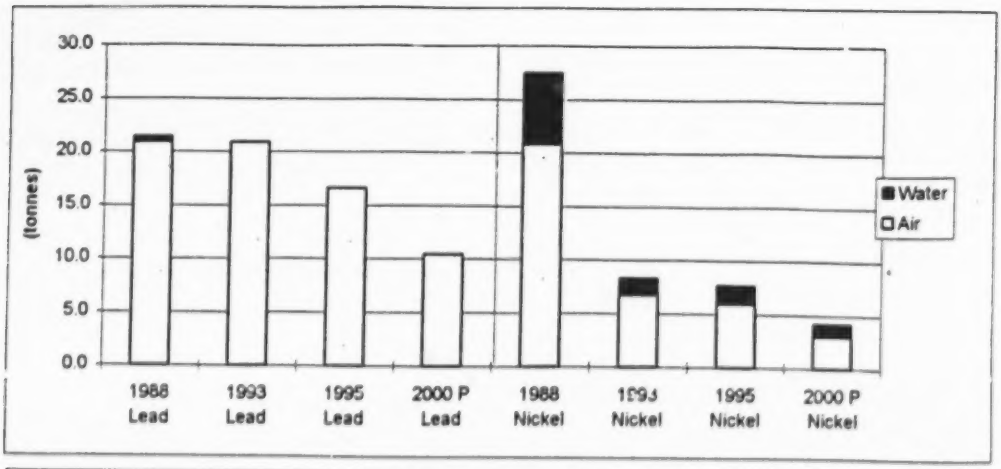
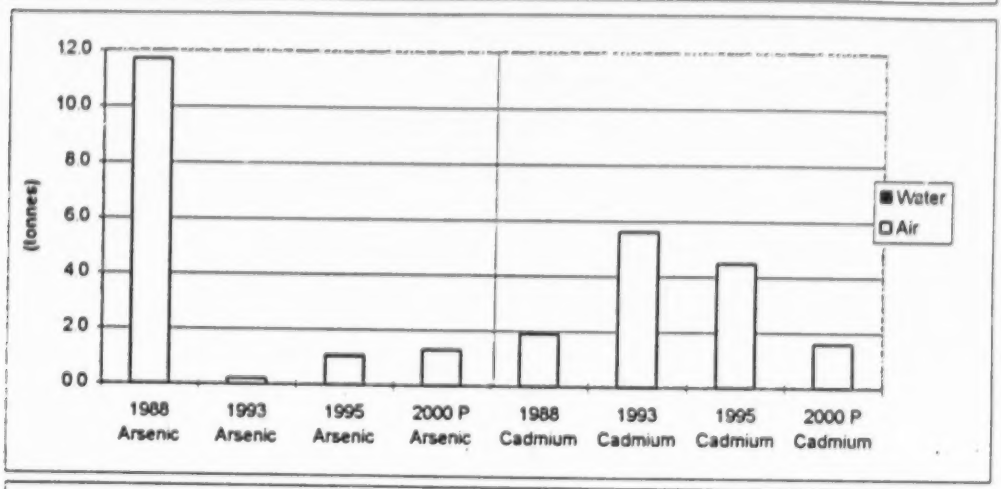


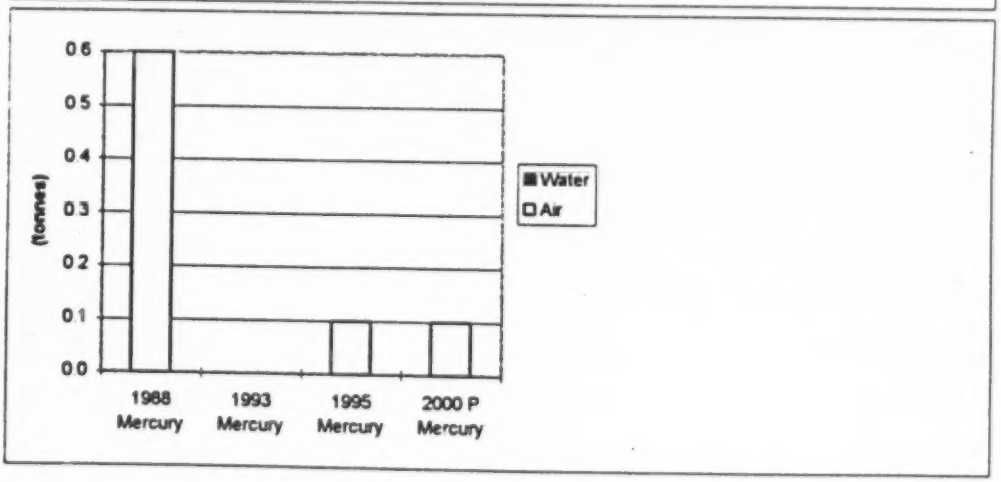
Table A6.6.2 **Releases to Air and Water and Off-site Transfers by Falconbridge Ltd., Sudbury, Ontario (tonnes) (Ni-Cu Smelter)**

Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	11.7	0.2	1.0	1.3
Water Releases	0.0	0.0	0.0	0.0
Total Releases	11.7	0.2	1.1	1.3
Transfers Off-site		0.0	0.0	0.0
Cadmium				
Air Releases	1.9	5.6	4.5	1.6
Water Releases	0.0	0.0	0.0	0.0
Total Releases	1.9	5.6	4.5	1.6
Transfers Off-site		0.0	0.0	0.0
Lead				
Air Releases	20.9	20.9	16.6	10.4
Water Releases	0.5	0.0	0.0	0.0
Total Releases	21.4	20.9	16.6	10.4
Transfers Off-site		0.0	0.0	0.0
Mercury				
Air Releases	0.60	0.00	0.10	0.10
Water Releases	0.00	0.00	0.00	0.00
Total Releases	0.60	0.00	0.10	0.10
Transfers Off-site				0.00
Nickel				
Air Releases	20.8	6.7	5.9	3.0
Water Releases	6.7	1.6	1.8	1.2
Total Releases	27.5	8.3	7.7	4.2
Transfers Off-site		0.0	0.0	0.0

Figure A6.6.2 Falconbridge, Sudbury Releases to Air and Water.







The smelter effluent is subject to the general prohibition of deposits of deleterious substances in Subsection 36 (3) of the Fisheries Act. Effluent quality is also subject to the Guidelines for the control of Liquid Effluent Quality from Existing Metal Mines under the Fisheries Act. Effluent quality will also be regulated by Ontario when the MISA Limits Regulation for the Metal Mining Sector under the Environmental Protection Act comes into force in 1997. Wastewater concentrations of nickel and total suspended solids are below both the objectives specified by the federal guidelines and the limits specified by the provincial regulation.

Falconbridge accepted the ARET challenge in 1994 and submitted an action plan that detailed specific goals for each substance. Falconbridge's goals are annually reviewed, updated and reported to ARET.

Program And Plans

1989	Rebuilt the electrostatic precipitator resulting in improved dust collection efficiency.
1990	Changed reagents at the Moose Lake effluent treatment plant, resulting in reduced nickel and other metal concentrations in effluent.
1994	Modified No. 1 electric furnace, including improved gas offtake, larger ducting and high efficiency cyclones to handle increased gas volumes. Modifications facilitated increased matte metallization, higher degree of roasting in the fluidized bed roasters and reducing sulphur dioxide emissions from the smelter.
1995	Upgraded electric furnace inlet flue and installed downcomer water sprays in the electric furnace off-gas flues to increase matte metallization and increase off-gas volume.
1997-2000	Program of continual improvement to reduce particulate emissions, including installation of new larger primary converter hoods to reduce fugitive emissions of particulate from the converter aisle and a new baghouse to collect particulate emissions from the matte end exhaust.
Beyond 2000	Program of continual improvement, including improvements to the electrostatic precipitator and upgrade of electric furnace No. 2, including ground monitor and metallurgical controls.

Issues

The smelter will be increasing its production of nickel by close to 50% as a result of processing the Raglan concentrate from northern Quebec. The Raglan mine is scheduled to start production of concentrate in December 1997 with the first concentrate to be shipped to Sudbury late in the first quarter of 1998.

The smelter is being modified in order to be able to handle this additional material. Some bulk samples have been processed and the information gained from this have been incorporated into the modifications to the smelter. However, as is usual in these of situations, there can be startup and other unanticipated challenges as a result of processing the additional tonnage of ore from a new mine.

The following other issues could affect the smelter operations in the future:

- Meeting the ARET commitments.
- Removal of Control Order will result in lower SO_2 GLC's and may impact on future production levels.
- Revisions to Ontario Regulations 337 and 346 with respect to GLC's for various metals.
- H_2S removal.
- Wastewater sludge and slag management.

Technical Options To Achieve Further Release Reductions

Improvements are being planned to reduce emissions from the furnace matte end exhaust through the installation of a new baghouse. Additional primary hooding is being put in place and this will reduce the release of fugitive emissions. Substantial modifications are also being planned to the Cottrell plant.

Other technical options are constantly being examined as part of the ongoing process for continuous improvements at the smelter.

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6.7 INCO LIMITED SUDBURY/COPPER CLIFF OPERATIONS COPPER CLIFF, ONTARIO

Profile

The Inco operation at Sudbury Ontario is an integrated mining, milling, smelting and refining operation. The primary products of the operation are nickel, copper and cobalt with a byproduct production of precious metals. The original smelter dated from the 1930s with the technology of the time being multi hearth roasters and reverbatory furnaces for smelting with Peirce-Smith converters for finishing. In the 1990s a major rebuild of the Smelter changed the process to flash furnace technology. The Copper Refinery is a conventional anode furnace smelting with electrorefining of anodes in a tankhouse, and has undergone significant upgrading in the last decade. The Nickel Refinery came on line in the 1970s with top blown rotary converters and the Inco pressure carbonyl process for final refining.

Process Description

Smelter

The Smelter treats bulk nickel-copper concentrate by drying filter cake in fluid bed dryers and then flash smelting this material with silica flux (sand) and technical oxygen in flash furnaces. The slag from the furnaces is skimmed to railcars and transported to a cooling area where it is later removed for use as aggregate in railbeds and roads. The sulphide matte from the flash furnaces is transported to the Peirce-Smith converters by ladle and further oxidized for iron and sulphur removal. The slag from the converting stage is returned to the flash furnaces for metal recovery. The finished matte from the converters is slow cooled in large ingots to allow growth and selective precipitation of nickel sulphide, copper sulphide and metallic crystals. These ingots are crushed, ground and processed by magnetic separation and flotation to concentrates of nickel sulphide, copper sulphide and a metallic copper nickel fraction. The nickel sulphide fraction is roasted in fluid bed roasters to produce a nickel oxide product suitable for the steel industry. The copper sulphide fraction is processed by flash converting and finishing converting to produce blister copper which is refined at Inco's Copper Refinery. The metallic fraction is processed further at Inco's Nickel refinery.

Nickel Refinery

The metallic nickel-copper fraction from the Smelter is the primary feed for the Nickel Refinery, which is smelted with oxygen in top blown rotary converters to remove residual sulphur, then granulated in water and conveyed to the Inco pressure carbonyl refinery. The nickel in the granules is extracted with carbon monoxide at high pressure and forms nickel carbonyl. The nickel carbonyl is distilled into two fractions; nickel carbonyl and nickel-iron carbonyl which are decomposed into pellets and powder for sale to market. The residue from the extraction process is pumped to the Electrowinning Plant at the Copper Refinery.

Copper Refinery

Blister copper from the smelter is transported in a molten state in insulated rail cars to the Copper Refinery anode furnace. In the furnace oxygen levels are reduced by poling and the copper is cast as anodes for electrorefining to cathodes. The cathodes are a market product. The residue pumped from the Nickel Refinery to the Electrowinning Plant is leached and electrowon to recover copper, with the remaining residue sent to the Port Colborne Refinery for further metal recovery.

Releases

Releases are detailed in Table A6.7.1 and Figure A6.7.4.

The offgases from the fluid bed dryers are treated for particulate removal in baghouses. The flash furnace offgases are treated in a wet process for particulate removal and sent to the acid plant for sulphur dioxide removal. Process gases from the converting stage are treated in electrostatic precipitators for particulate removal and then vented to atmosphere. These gases contain lower concentrations of sulphur dioxide that together with their intermittent flow make them unsuitable for acid plant feed. In addition low strength fugitive emissions are removed from the workplace by venting to atmosphere. The process gases from the fluid bed roasters are treated in cyclones and electrostatic precipitators for particulate removal and then vented to atmosphere.

The Nickel Refinery top blown rotary converter off gases are processed in electrostatic precipitators for particulate removal prior to release to the atmosphere.

The Copper Refinery anode furnace emissions are not currently treated prior to venting to atmosphere.

Water discharges are minimized by extensive recycling. Excess water is treated with lime for metal precipitation prior to release into the environment.

Regulatory and Non-Regulatory Programs

Environmental aspects of Incos operations in Sudbury are regulated by the Ontario Ministry of the Environment and Energy. These regulations include a sulphur dioxide emission cap of 265 kilotonnes specified in an Inco control order. Numerous Certificates of Approval govern individual emission sources. In addition the Ontario Environmental Protection Act (EPA) Regulations specify Point of Impingement Standards for the *CEPA* Substances under review.

Water discharges are generally covered by Provincial Discharge Permits with one exception; a Letter of Concurrence in lieu of a discharge permit. In addition the Guidelines for Control of Liquid Effluent Quality from Existing Metal Mines under the

Fisheries Act apply to a portion of the water discharges. Effluent quality will also be regulated in 1997 by Ontario under the MISA Limits Regulation for the Metal Mining Sector under the EPA.

Monitoring and Research

Extensive research was conducted in the 1980s on smelting processes prior to the major rebuild of the Copper Cliff Smelter in the 1990s. Other research on air emissions from the Fluid Bed Roasting Plant has extended back to 1975 and is currently being repeated in a modified configuration to determine the most feasible design for particulate capture. Tests were carried out in 1996 and continue into 1997 at the Copper Refinery on the anode furnace emissions. This testwork is evaluating the feasibility of particulate capture on the furnace emissions.

Extensive characterization of water discharges was carried out in the early 1990s in preparation for MISA Limits Regulation for the Metal mining sector under the Environmental protection Act.

Programs and Plans

1991-1994 Major rebuild of the Copper Cliff Smelter. This included a Mill rationalization which increased pyrrhotite rejection and reduced the quantity of materials processed by the Smelter. In addition the Smelter switched to flash smelting technology for bulk concentrates and copper sulphide reverts. This change included major modification and replacement of some electrostatic precipitators as well as the construction of an acid plant for sulphur dioxide capture. This work was carried out at a cost of $600 million.

1980-1997 Ongoing design changes to hoods for nickel converters to control fugitive emissions and improve gas strength to permit utilization in an acid plant.

1996-1997 Testwork on Copper Refinery anode furnace emissions to determine best technology for particulate capture.

1997 Testwork on the Fluid Bed Roasting Plant emissions to determine best technology for particulate capture.

1997 Preparatory work for the implementation of the MISA Regulations including monitoring, testwork and changes to water treatment prior to discharge.

Figure A6.7.1 Inco Copper Cliff Nickel/Copper Smelter Process Flow Sheet

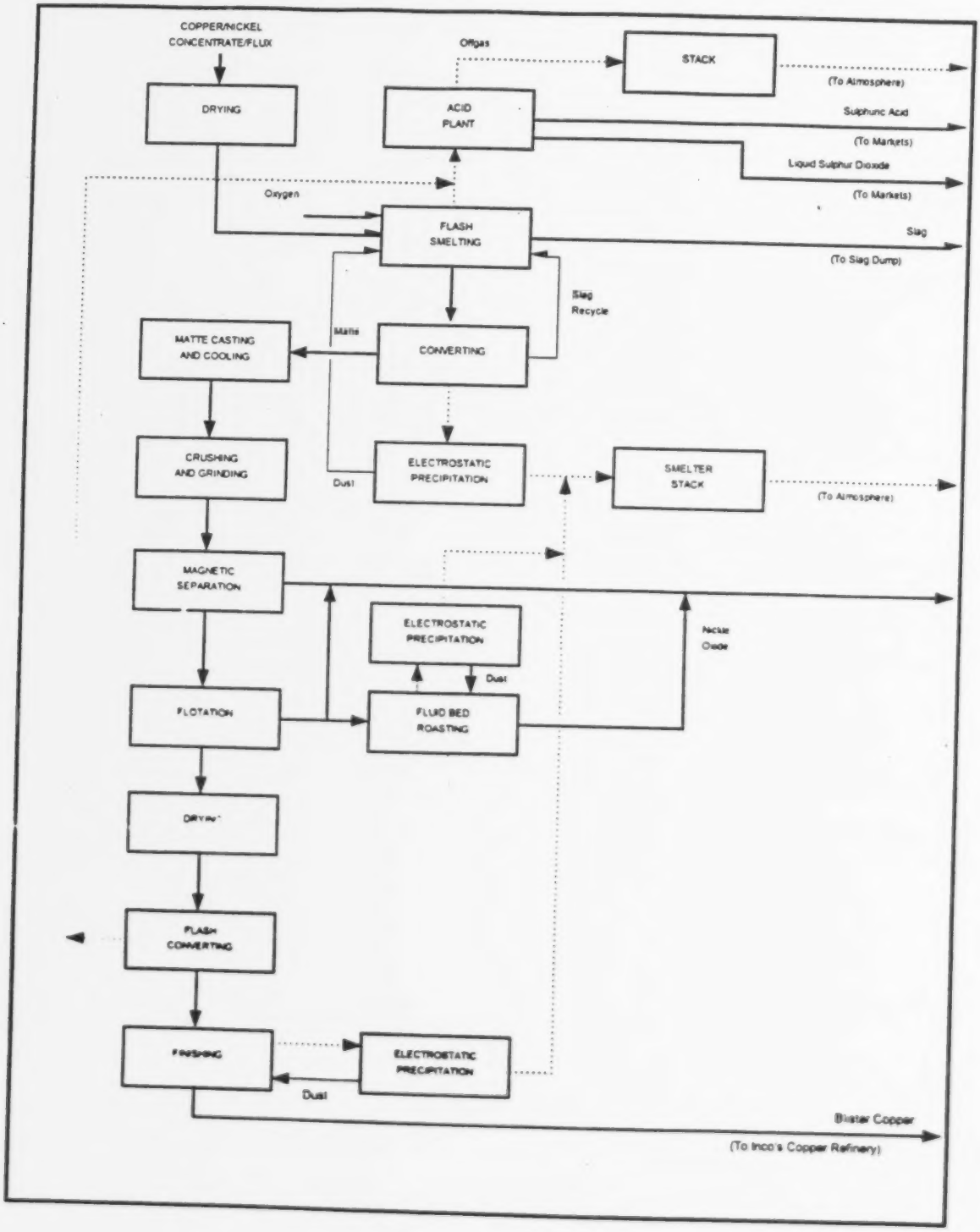


Figure A6.7.2 Inco Copper Cliff Copper Refinery Process Flow Sheet

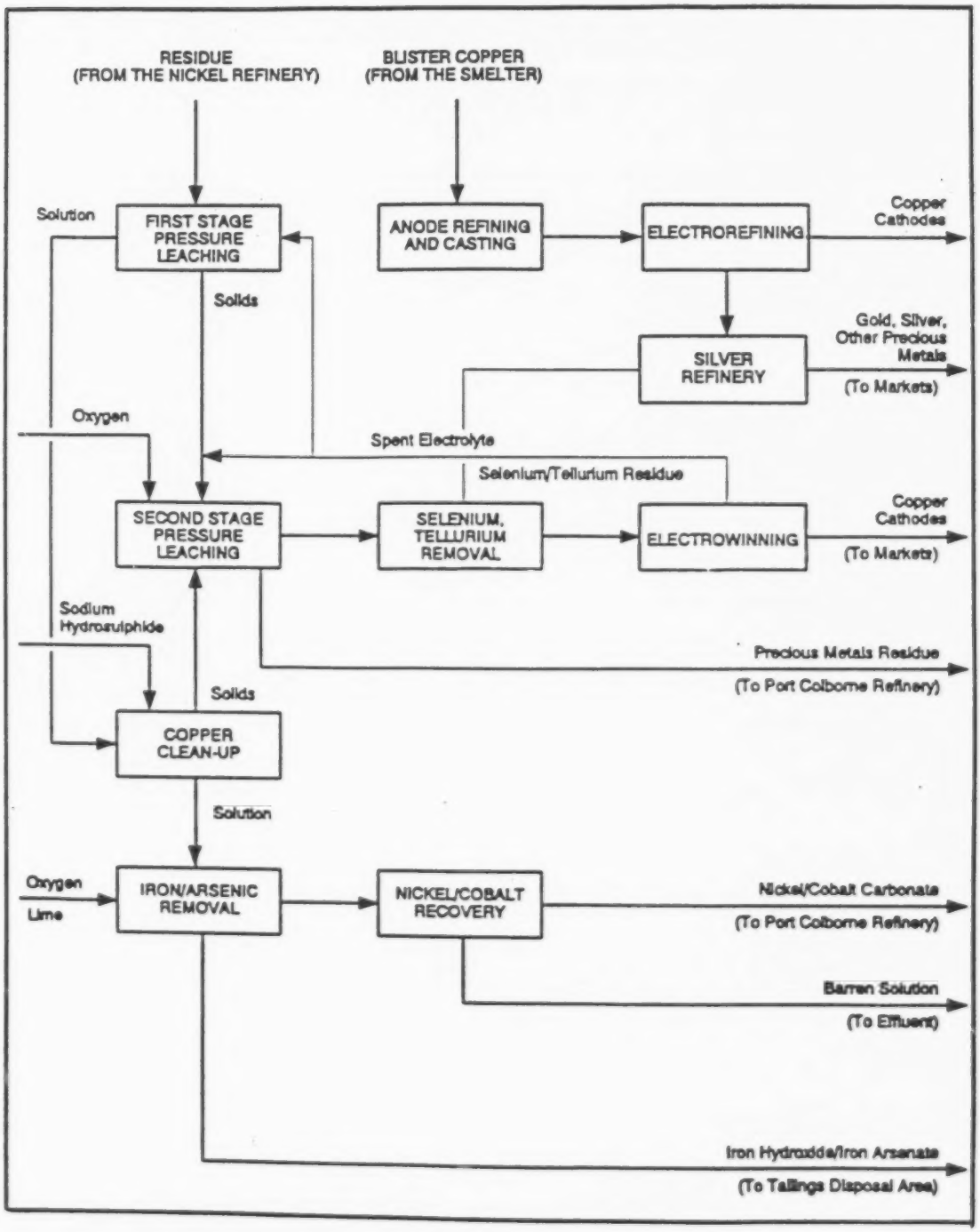
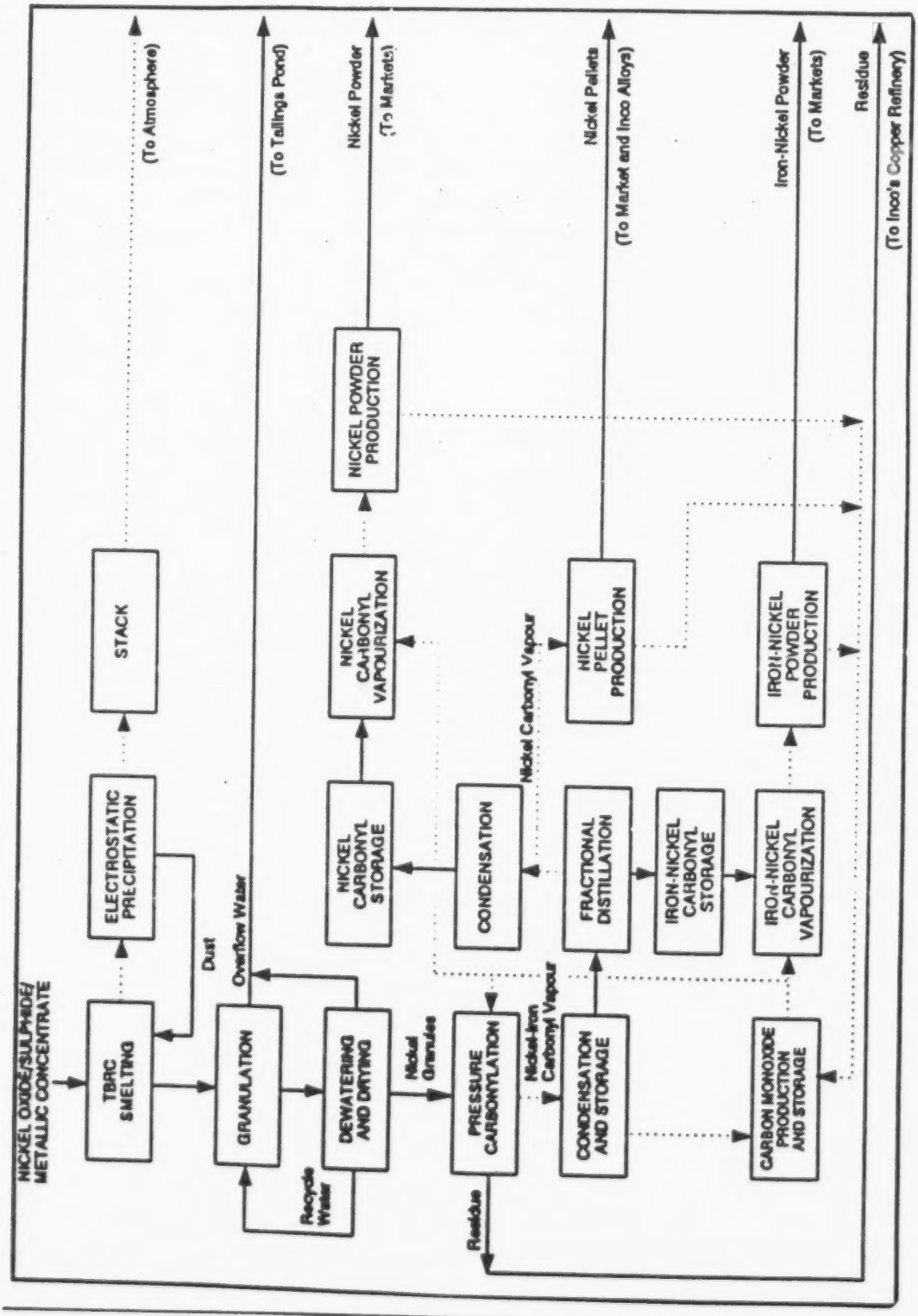


Figure A6.7.3 Inco Copper Cliff Nickel Refinery Process Flow Sheet



Issues

The Base Metal Smelting Sector represents plants with unique processes, different metallurgy and varying feedstocks. Although some control technologies are applicable in general use for the most part the solutions are not directly transferable to other facilities. Past reductions in emissions have required research into basic processes, new control technologies and better materials of construction. Further reductions will require development of effective and economical methods to control emissions with consideration of their impact on the process and the ability to compete in the metal markets.

Any work planned for the future must anticipate the impact of other initiatives such as the Acidifying Emissions Taskforce as well as the current review of particulate size considerations. These initiatives can change the selection of technologies for emission reduction.

Technical Options to Achieve Further Release Reductions

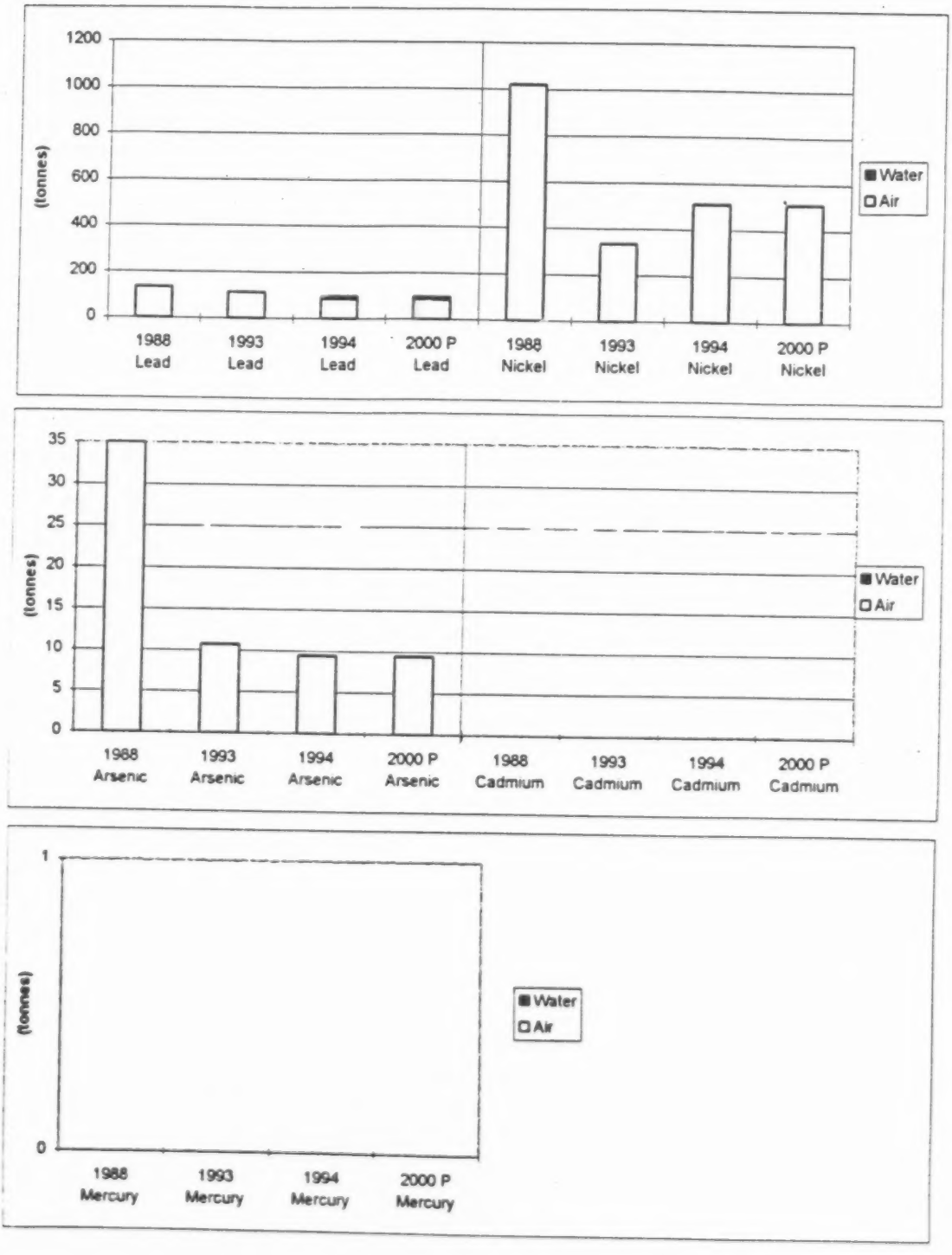
The testwork detailed above will determine the technical and economic feasibility of the control equipment under study.

Table A6.7.1 **Releases to Air and Water and Off-site Transfers by Inco Copper Cliff, Ontario (tonnes) (Ni-Cu Smelter and Refineries)**

Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	35.0	10.6	9.4	9.4
Water Releases	0.0	0.1	0.1	0.1
Total Releases	35.0	10.7	9.5	9.5
Transfers Off-site		0.0		
Cadmium				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Lead				
Air Releases	133.0	111.9	84.3	84.3
Water Releases	0.0	0.1	12.0	12.0
Total Releases	133.0	112.0	96.3	96.3
Transfers Off-site		0.0		
Mercury				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Nickel				
Air Releases	1019.0	334.3	509.7	509.7
Water Releases	0.3	0.6	0.6	0.6
Total Releases	1019.3	335.0	510.3	510.3
Transfers Off-site		0.0		

Note.
Smelter and copper refinery effluent goes to tailings pond with mine /mill effluent and is attributed to mine/mill.
1988 Nickel refinery effluent is discharged seperately.
No projections for 2000 were provided by Inco. As the information is not currently available. Inco is undertaking studies to determine future reductions of releases.
For the purpose of calculating 2000 projections for whole sector, 1995 data has been used for the year 2000.

Figure A6.7.4 Inco Copper Cliff Releases to Air and Water



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6.8 INCO LIMITED PORT COLBORNE, ONTARIO

Profile

The Inco operation at Port Colborne Ontario is composed of refining operations for cobalt and precious metals.

Process Description

The Port Colborne facility commissioned a Cobalt plant in the 1980s which was constructed as a best available technology hydrometallurgical plant.

The other plant located at the site is a precious metals refinery which is also a hydrometallurgical process.

The nickel remelt furnaces were shut down in July 1995 and have since been removed. The refinery input/output diagram is shown in Figure A6.8.1.

Releases

Releases are detailed in Table A6.8.1 and Figure A6.8.2.

There are no major air emission sources at the site. Individual process requiring venting are treated by wet scrubbing prior to release.

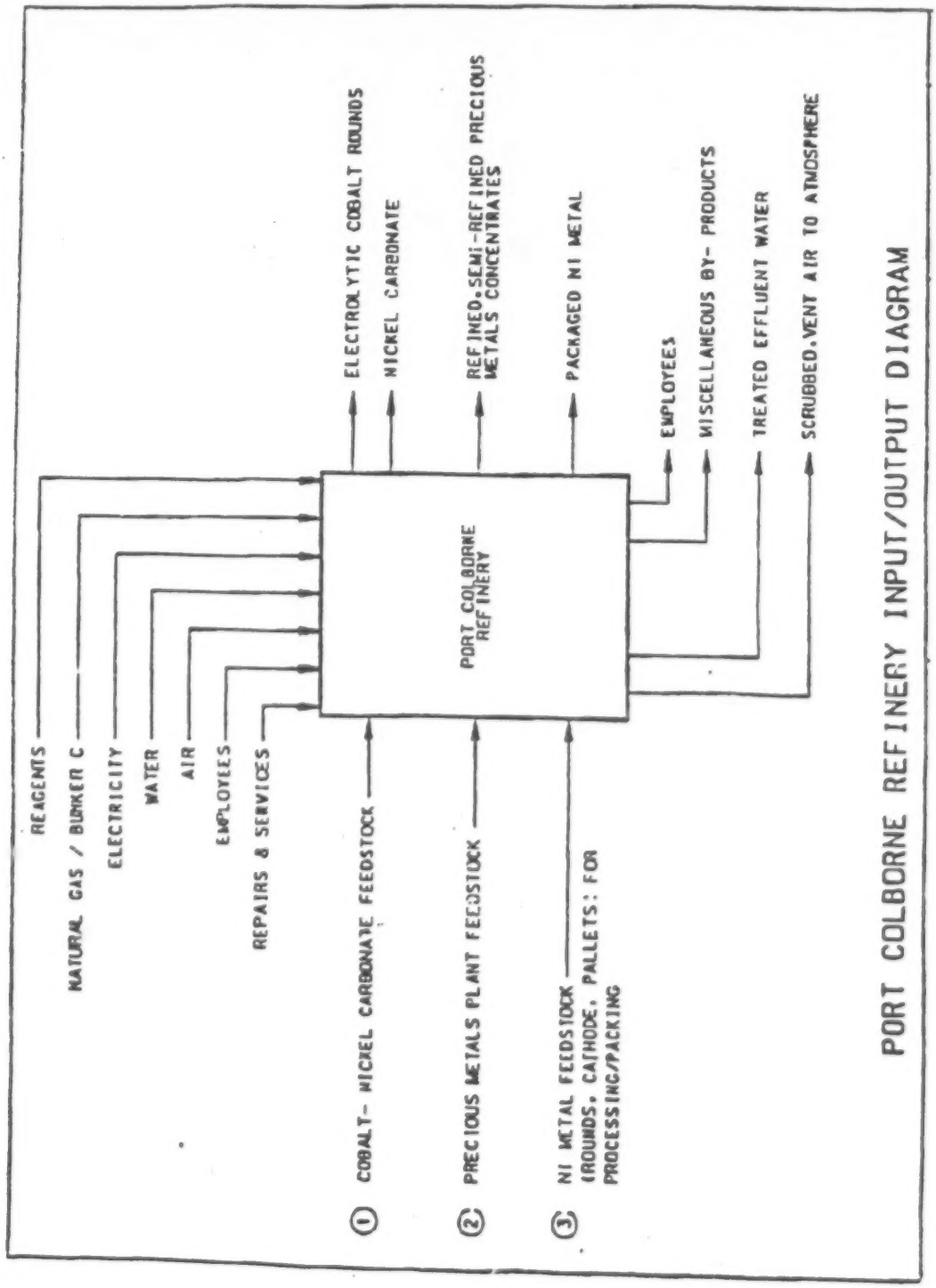
The waste water treatment plant treats effluents from both plants as well as treating surface runoff from the site. The treatment is a lime adjustment of pH for metal removal.

Regulatory and Non-Regulatory Programs

Environmental aspects of Incos operations in Port Colborne are regulated by the Ontario Ministry of the Environment and Energy. Certificates of Approval govern individual emission sources. In addition the Ontario Environmental Protection Act (EPA) Regulations specify Point of Impingement Standards for the *CEPA* substances under review.

This facility constructed the waste water treatment plant under the authority of a Certificate of approval and is currently governed by the IMIS Guidelines. Effluent quality will also be regulated in 1997 by Ontario under the MISA Limits Regulation for the Metal Mining Sector under the EPA.

Figure A6.8.1 Inco Port Colborne Cobalt Refinery Process Flow Sheet



Monitoring and Research

Extensive characterization of water discharges was carried out in the early 1990s in preparation for MISA Limits Regulation for the Metal mining sector under the Environmental protection Act.

Programs and Plans

1997 Preparatory work for the implementation of the MISA Regulations including monitoring, testwork and changes to water treatment prior to discharge.

Issues

This facility uses best available technology hydrometallurgical processes. There are no major air emission sources at this site. Other issues relate to management of site runoff and will be addressed through continual improvement programs on an ongoing basis.

Any work planned for the future must anticipate the impact of other initiatives such as the Acidifying Emissions Taskforce as well as the current review of particulate size considerations.

Technical Options to Achieve Further Release Reductions

No clear options exist at the present time as this facility currently uses best available technology.

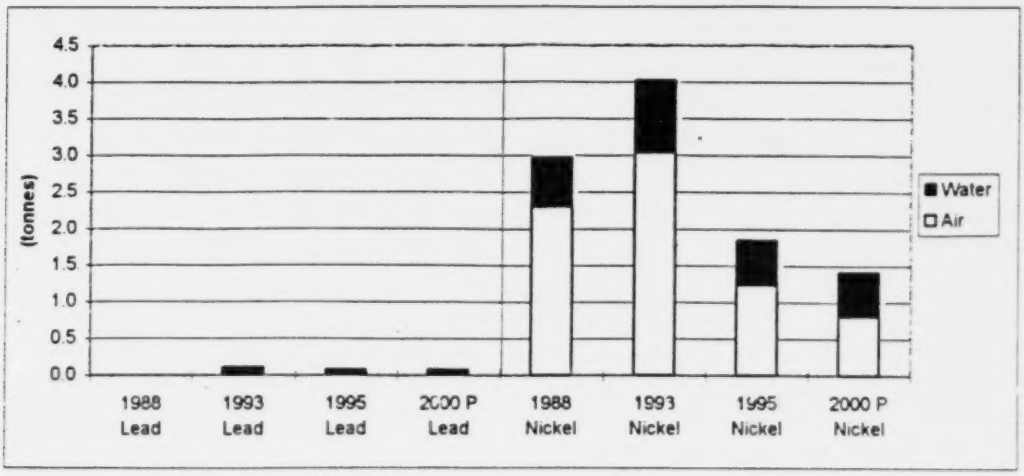
There is an active program at the site for review of environmental priorities. This program will continue to review issues and technology available to further reduce emissions.

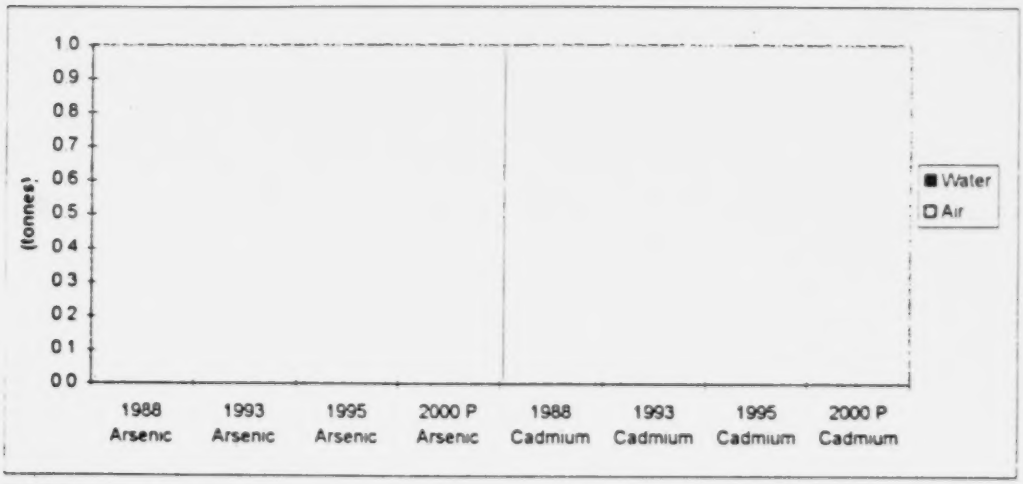
Table A6.8.1 **Releases to Air and Water and Off-site Transfers by Inco Port Colborne, Ontario (tonnes) (Cobalt Refinery)**

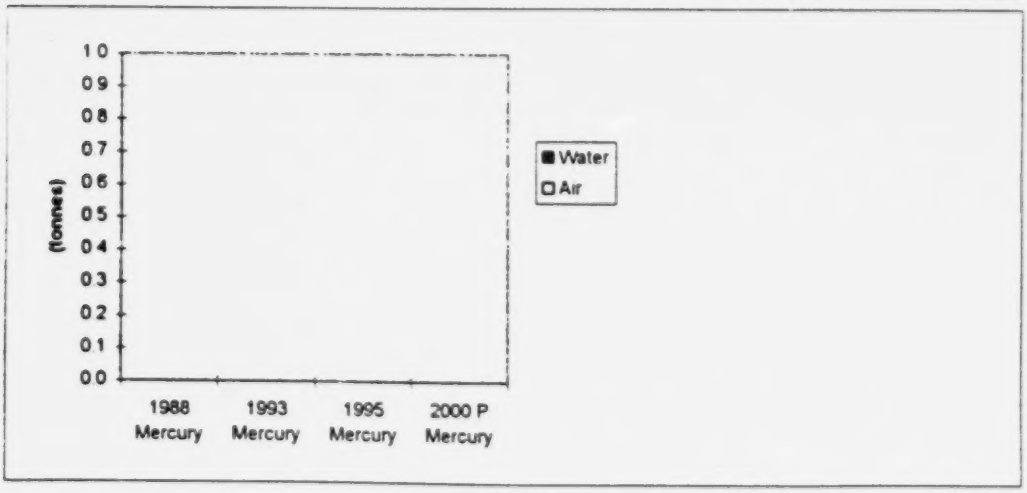
Year	1988	1993	1995	2000 P
Arsenic				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Cadmium				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Lead				
Air Releases		0.0	0.0	0.0
Water Releases		0.1	0.1	0.1
Total Releases	0.0	0.1	0.1	0.1
Transfers Off-site		2.2	0.7	
Mercury				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Nickel				
Air Releases	2.3	3.0	1.2	0.8
Water Releases	0.7	1.0	0.6	0.6
Total Releases	3.0	4.0	1.8	1.4
Transfers Off-site		0.0	0.0	

2000 Projections:
The plant was modified in 1995 and shut down pyrometallurical operations.
Projections for 1996 have been used as the projections for 2000.

Figure A6.8.2 Inco Port Colborne Releases to Air and Water







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6.9 TONOLLI CANADA LTD. MISSISSAUGA, ONTARIO

Profile

Tonolli Canada Limited (Tonolli) was incorporated in 1958 as a first venture in North America of an Italian family corporation dating back to the late 1800's. The secondary lead smelter continues on its original site at 2414 Dixie Road in the City of Mississauga. The company provides permanent employment to 75 people and currently processes some 60,000 tonnes of spent lead acid batteries per annum to generate 35,000 tonnes of lead and lead alloys. The operation enjoys an excellent record of compliance with local, provincial and federal regulations. Tonolli recently invested $6 million in process improvements principally designed to bring about additional reductions in the amount of sulphur emitted from waste battery smelting as well as in the volume of slag generated. These improvements also lowered the cut-off grade of recyclable lead battery scrap, thereby increasing the recycling rate of such scrap as well as enlarging the trading area in which scrap can be economically collected.

Throughout its existence, the company has met or exceeded mandated environmental standards. It counts among the technologically most advanced lead acid batter recycling organizations in the world.

Selected production data for the period 1993 to 1995 are presented in Table A6.9.1, which includes projected levels for the year 2000.

Table A6.9.1 Production Summary (tonnes)

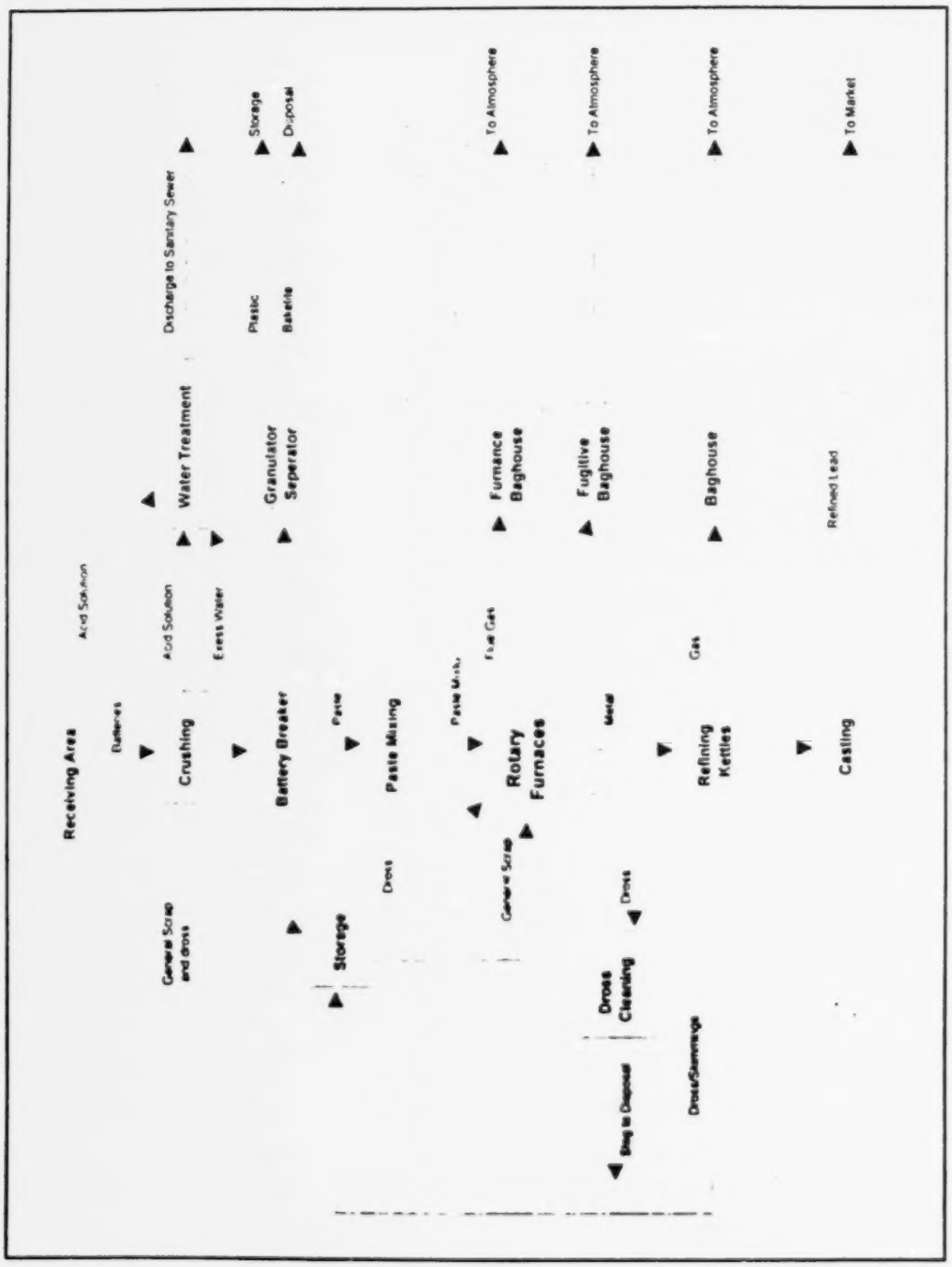
Product	1993	1995	2000 (projected)
Lead	24,000	30,000	48,000

Process Description

Batteries are dumped from an elevating ramp into an enclosed building with negative ventilation where they are pre-crushed with a bulldozer to remove most of the acid solution. This acid solution and rainwater run-off from lead working yards are collected in two lined ponds. It is treated with caustic soda and filtered through activated carbon columns before being discharged into the sanitary system of the Region of Peel.

Pre-crushed batteries are then processed through as battery breaking and sorting plant. The resulting materials are lead oxide and lead sulphate, called paste and metallic hard lead called grids which are smelted in rotary furnaces and then further refined. Polypropylene casings are crushed, washed and sold to plastic recyclers. Hard rubber mixed with separators and wood pieces from pallets are crushed, washed and disposed of by an approved waste hauler.

Figure A6.9.1 Tonolli Secondary Lead Smelter Process Flow Sheet



Releases

All point sources of releases to air and water from the smelter and refinery are shown on Figure A6.9.1 and controlled as outlined below.

All process off-gases are controlled by baghouses except for the battery breaker which is controlled by a wet scrubber. Concentrations of lead in all exit releases are less than 1 mg/m3. Total lead released based on lead production is less than 0.1 Kg /tonne of lead produced (Questionnaire response).

All effluent, including storm water from the smelter site is collected, treated and monitored.

Selected release data for the period 1990 to 1995 are presented in Table A6.9.2 and Figure A6.9.2 and projected levels for the year 2000 are included.

Regulatory and Non-Regulatory Programs

The lead smelter and refinery are subject to the Secondary Lead Smelter Release Regulations under the Canadian Environmental Protection Act, which establish legally enforceable limits for particulate emissions containing lead. The regulations require monitoring and reporting. Tonolli has been in full compliance with the regulation.

The lead smelter and refinery are also regulated by the Province of Ontario. The Certificate of Approval (Air), Number 8-3168-96-006, issued to Tonolli under the authority of Section 9 of the Environmental Protection Act, outlines the terms and conditions with respect to the operation and maintenance of all air pollution control equipment on site. Recordkeeping and reporting requirements are also detailed.

Tonolli is also subject to waste registration provisions of Ontario Regulation 309. Specified wastes must be managed at approved sites.

Monitoring and Research

Ambient air quality is measured by particulate hi-vol samplers. An array of monitors are located at various locations in the vicinity of the facility. Tonolli complies with the ambient air quality criteria which calls for a monthly geometric mean for lead of two micrograms per cubic meter and a twenty four hour maximum of five micrograms per cubic meter.

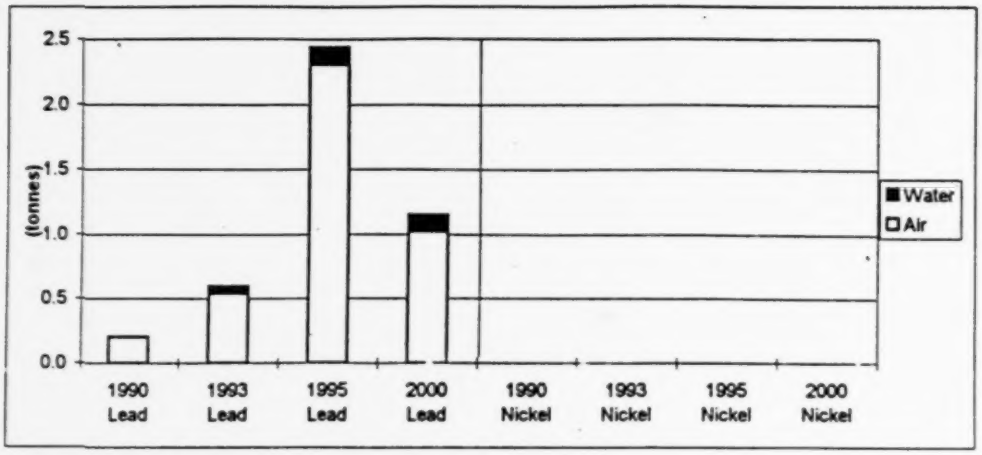
A Lear Siegler Monitor mounted on the main stack which exhausts the smelting and refining flue gases, provides a continuous read-out of the stack gas opacity.

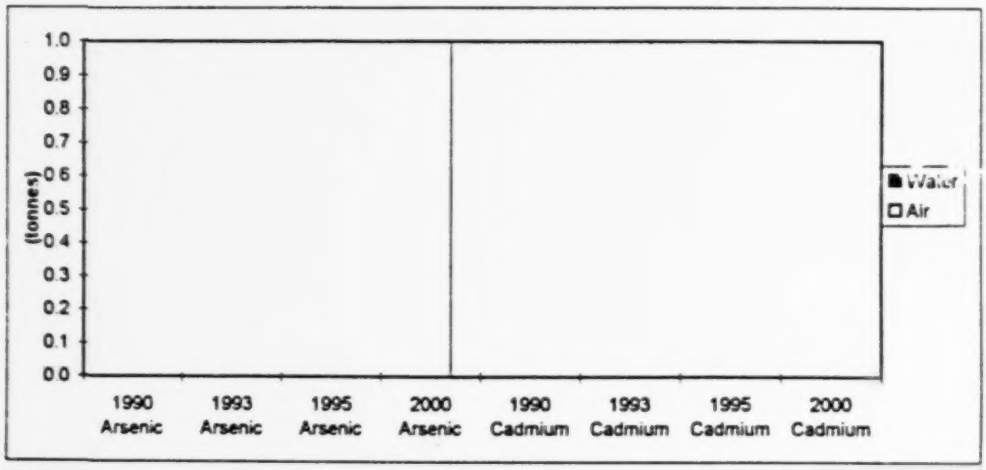
Table A6.9.2 **Releases to Air and Water and Off-site Transfers by Tonolli Canada Ltd., Mississauga, Ontario (tonnes) (Lead Smelter)**

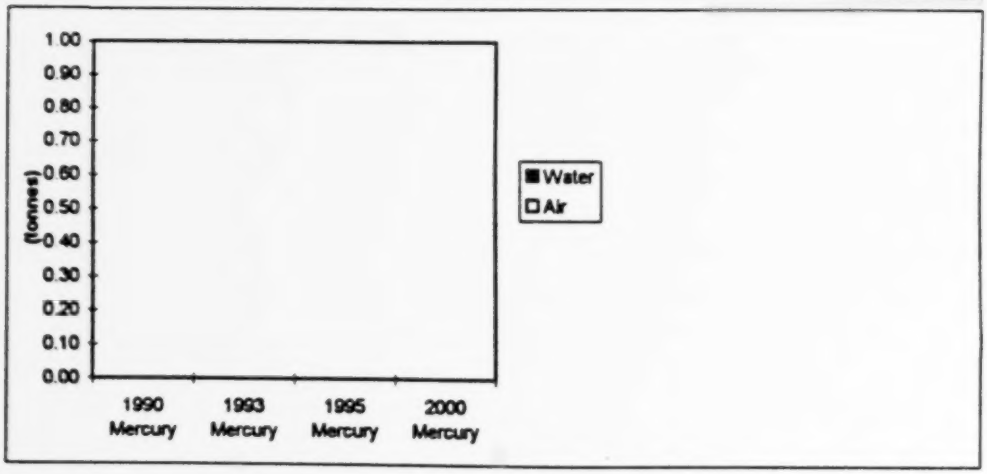
Year	1990	1993	1995	2000 P
Arsenic				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Cadmium				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Lead				
Air Releases *	0.2	0.5	2.3	1.0
Water Releases		0.1	0.1	0.1
Total Releases	0.2	0.6	2.4	1.2
Transfers Off-site		179.3	226.9	300.0
Mercury				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Nickel				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				

* 1990 Air Release included only stack emissions, but not fugitive emissions.
1990 Data is provided; 1988 Data is not available

Figure A6.9.2 Tonolli Releases to Air and Water







Tonolli, in partnership with Engitec Impianti S.p.A., has been assessing the CX-EWS process for the electrochemical treatment of spent lead acid batteries by obtaining electrolytic lead and elemental sulphur. This new technology will allow for the first time the treatment in the same facilities of both primary lead sulphide concentrate and spent batteries.

Programs and Plans

Technical Changes 1988 - 1993

1988	New paste building storage. New wet batteries recovery system installation (CX Phase 1).
1988-1989	Double ventilation installed in paste batteries storage buildings. Double ventilation sanitary hoods in rotary furnace one(1), two (2) and three (3). Foundry refinery building natural roof vents closed and installed new ventilation to improve air circulation.
1988-1990	Oxy - fuel burner in rotary furnace one (1), two (2) and three (3) and upgrade ventilation system of the rotary furnace. New flue dust handling system (wet).
1990-1991	CX Phase II desulphurization plant with new building. New sprinkling system to wet down yard and dust boxes of refinery material by-products.
1993	Was an unusual year. Due to recession the company sold and /or traded the majority of paste, smelting only high metallic residues (70% grids). Therefore the company only operated five days per week with an average of 1 ½ furnaces running. In addition the plant was shut down for an extra month (April 93). This justifies the lower emission numbers.
1996	the company is going to collect all of the storm water and, after treatment, will discharge same into the sanitary sewers
1997	The company will cover the area where the slag generated from the rotary furnaces is cleaned prior to being disposed of - a source of 85% of the existing fugitive emissions.

Technical Changes Beyond 2000

Air Emissions

Researching and economically assessing the CX-EWS process. This is a new process for the electrochemical treatment of the spent lead acid batteries by obtaining electrolytic lead and elemental sulphur. This technology would effectively eliminate air releases. See paper presented on CX-EWS process by Engitec Impianti S.p.a. at the Third International Symposium on Recycling of Metals and Engineered Materials.

Water

All storm water releases will be eliminated by 2000. Treatment of storm water will be implemented and discharged through sanitary sewers after 2000.

Table A6.9.3 discusses the technical options for further reductions at this facility.

Issues

As secondary lead smelters, we are already subject to specific Federal regulations and we accept that these regulations are maintained without any changes.

No further emission reductions should be considered for secondary lead smelters at this time.

It is vital that we are precise and clear in our position that any company that utilizes secondary lead material in and/or with their process, should be subject to the same norms as exist for secondary lead smelters.

We should be excluded from any further reduction of the five (5) metals (As,Cd,Ni,Pb,Hg) until the Primaries (Primary Base Metal Sector) meet the standard applicable to Secondary smelters.

Technical Options to Achieve Further Release Reductions

See Table A6.9.3

Table A6.9.3 Technical Options for Air Emissions from Tonolli

	Technical Option	Description	Applicability Code (1) and date	Applicability Comment	Potential Reduction % (2)	Capital Cost (3) (million $)
1	Improve Management and Operatin		E	Need to conduct site visit to determine options available		
2	Improve Existing Gas Cleaning System		E			
3	Install Dry Gas Cleaning Equipment					
4	Install Fugitive Emission Control	Cover slag disposal area	P (1997)		85%	
5	Install Wet Gas Scrubbing Equipment					
6	Install Acid Plant		No			
7	Reduction at Source through improvements to Existing Process or Equipment					
8	Modernize Process Equipment combined with state-of-the-art gas processing	Install new CX-EWS process	A	In research phase	100%	46.8 (150,000 t/y facility)
9	Change Feed Stock		No			

1 Applicability: E Existing, P Planned, A Likely Technically Applicable, No not Technically Applicable
2 Potential Reductions are relative to this gas stream based on existing technology (i.e., current releases)
3 Operating costs are estimated to be 10% of the capital costs per year.

6.10 NORANDA METALLURGY INC. HORNE SMELTER ROUYN-NORANDA, QUEBEC

Profile

Noranda Metallurgy Inc., Horne Smelter, operates a copper smelter in Rouyn-Noranda, Quebec. The plant started production in 1927 to process copper concentrates produced by an associated mine-mill complex. Prior to the 1970s, the smelter utilized conventional copper smelting technology including reverberatory furnaces and Peirce-Smith converters. Development and installation of Noranda's patented reactor for the treatment of copper concentrates permitted the gradual elimination of the reverberatory furnaces. The mine closed in 1976, and the smelter now processes custom and toll copper concentrates and secondary materials from a variety of sources world-wide. A sulphuric acid plant entered service in 1989. The smelter produces copper anodes and sulphuric acid. Selected production data for the period 1988 to 1995 are presented in Table A6.10.1, which includes projected levels for the year 2000.

Table A6.10.1 Production Summary (tonnes)

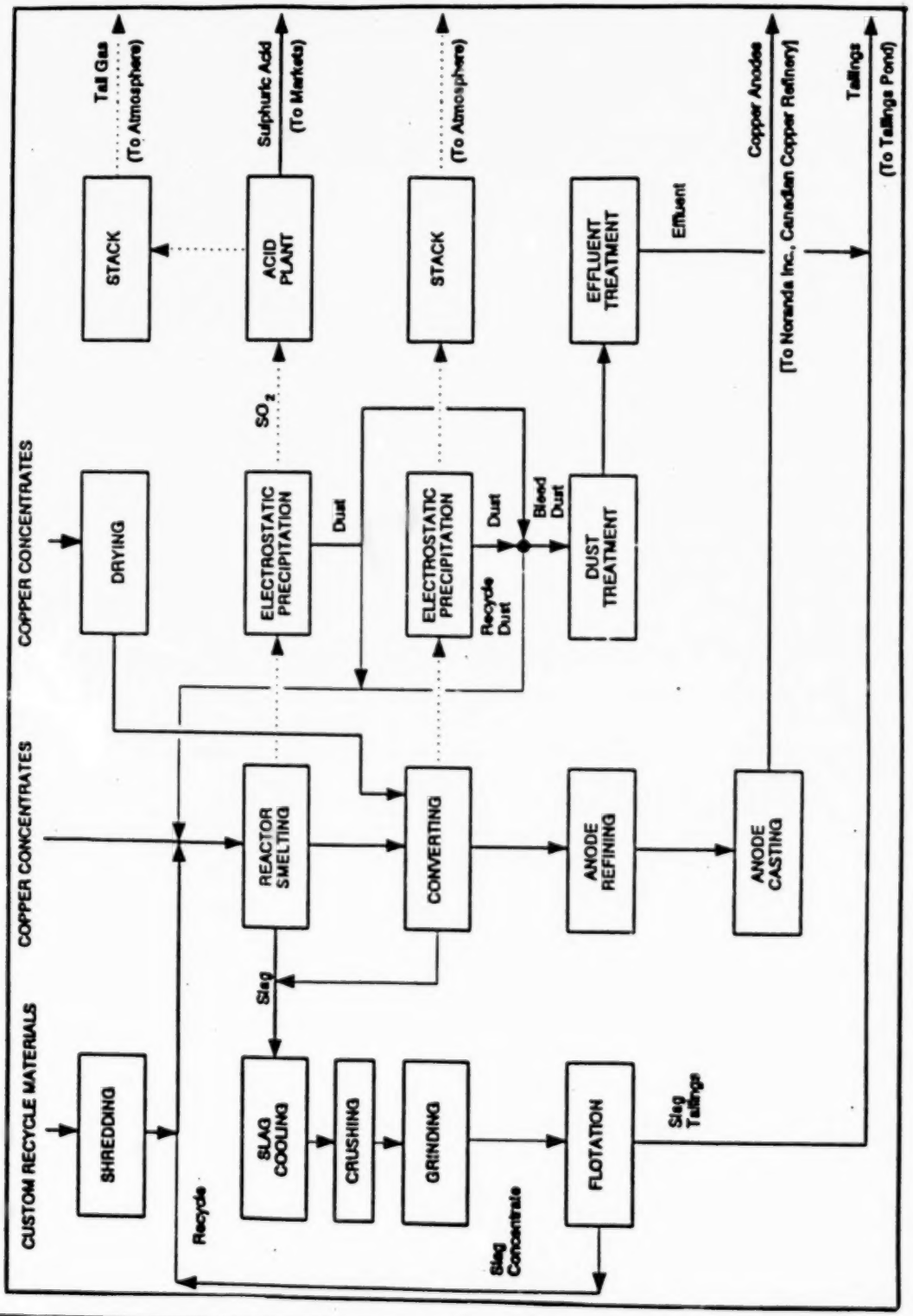
Products	1988	1993	1995	2000 (Projected)
Copper anodes	180,000	195,000	213,000	205,000
Sulphuric acid	0	407,000	416,000	510,000

Process Description

The process is outlined in Figure A6.10.1.

Copper concentrates and fluxing materials (silica) are proportioned to form a low viscosity FeO-SiO_2 slag with low copper content. New feed is mixed with recycled slag concentrate and dust from the smelter and processed in a single Noranda Reactor. Most of the copper in the smelter feed are contained in sulphide minerals and reports to the molten sulphide matte phase, while the bulk of the non-sulphide gangue forms an oxide slag containing copper at low, but economically recoverable concentrations. The higher density matte separates from the slag, which is combined with converter slag and is slowly cooled, ground and processed by flotation to recover most of the contained copper. Off-gases from the Noranda Reactor are treated by a dry electrostatic precipitator to remove particulate matter. The clean reactor off-gases are then directed to a single absorption sulphuric acid plant for recovery of sulphur dioxide.

Figure A6.10.1 Noranda Horne Copper Smelter Process Flow Sheet



Dust is returned to the reactor for recovery of copper and is also bled from the circuit to control impurity levels and reduce emissions. The gas cleaning section of the acid plant includes a mercury tower to minimize mercury emissions and ensure acid quality. Weak acid solution from the acid plant is neutralized with lime and mixed to react with a ferric sulphate solution to precipitate metals in solution, combined with mill tailings from slag flotation and co-deposited in the tailings impoundment area.

Matte is processed on a batch basis in Peirce-Smith converters to oxidize sulphur to sulphur dioxide and reduce copper to the metallic state. Oxygen-enriched air is used to convert iron sulphide to iron oxide, which combines with added flux to form an oxide slag and separates from the copper sulphide matte phase. This slag contains relatively high copper levels and is processed together with the slag from the Noranda Reactor to produce a slag concentrate that is returned to the reactor. As the converter cycle continues, copper sulphide is converted to blister copper containing dissolved sulphur and oxygen. Conversion of iron and copper sulphides produces converter off-gases containing substantial quantities of sulphur dioxide at concentrations which vary over the course of the batch operation. Converter off-gases are treated by a dry electrostatic precipitator to remove particulate matter. Dust is returned to the reactor for the recovery of copper, and is also bled from the circuit to control impurity levels and reduce emissions. The cleaned converter off-gases are released to the atmosphere. A portion of the copper concentrate feed is dried and injected directly into the Peirce-Smith converters to supplement the matte feed and maintain production capacity since the shutdown of the reverberatory furnaces.

The dust bleed stream containing copper, lead, cadmium, arsenic and other impurities is processed to recover valuable metals and then stabilized at the site. Effluents from dust treatment are treated by lime neutralization and ferric sulphate at the weak acid treatment plant, combined with mill tailings from slag flotation, and codeposited in the tailings impoundment area.

Blister copper is processed in an anode refining furnace to remove most of the dissolved oxygen and sulphur. The product is then casted into copper anodes, which are shipped to Noranda Metallurgy Inc.'s CCR Refinery in Montreal-East for electrolytic refining of copper and precious metals.

Releases

Point sources of releases to air and water from the smelter are shown in Figure A6.10.1 and controlled as outlined above.

Dry process gases from the Noranda Reactor and converters are treated by dry electrostatic precipitators for particulate control. Process gases from the reactor are treated and cleaned through a single absorption acid plant. Process gases from the converters containing lower concentrations of sulphur dioxide are not strong enough or

consistent enough in strength to be sent to an acid plant and are released to the atmosphere. These controls maintain vessels under negative pressure and reduce fugitive emissions from process equipment. All conveyors are fully enclosed to reduce fugitive emissions.

Major liquid effluents from the smelter site are collected and treated at the weak acid water treatment plant, combined with slag flotation concentrate tailings and are monitored. Other effluents are lime treated along with acid mine drainage from old sulphide mine tailings and are sent to polishing ponds and monitored.

Selected release data for the period 1988 to 1995 are presented in Table A6.10.2 and Figure A6.10.2 and projected levels for the year 2000 are included. Releases of *CEPA* substances decreased by over 60% from 1988 to 1995 and further release reductions are projected.

Some potential to form dioxins and furans exists at smelters with chlorinated plastics or other chlorinated substances in their feeds. Mechanical pretreatment can effectively separate metals and plastics contained in wire, but cannot separate copper from printed circuit boards or other electronic scrap. These particular materials constitute an important feed source for the Horne smelter.

This risk was anticipated by Noranda and Québec. Such materials are smelted only in the Noranda Reactor, and reactor off-gases are processed by an acid plant. Combustion parameters exceed design criteria established to minimize dioxin and furan releases from hazardous waste incinerators. Detailed and comprehensive sampling and analysis was conducted by or in the presence of provincial officials to verify performance over a wide range of operating conditions. Acid plant tail gas, weak acid and the intermediate and final effluents from the tailings pond were sampled and analysed for organic parameters selected by Québec, with the methodology based on methods published by the U.S. Environmental Protection Agency. An international toxic equivalent factor was used to express the results in terms of Toxic Equivalent 2, 3, 7, 8 PCDD/PCDF by calculation according to a method published by the North Atlantic Treaty Organisation. During the test periods, recyclable feed rates were as high as 64 t/h, exceeding the usual feed rate of 12 t/h by a factor of four to five. The results demonstrated that even at exceptionally high plastics feed rates, combined releases to air and water from the smelter would not exceed 0.1 g/y.

Regulatory and Non-Regulatory Programs

The copper smelter is regulated by the Quebec Ministry of Environment and Wildlife (MEF). An SO_2 emission standard of 276,000 tonnes/y (50% of the 1980 level) was implemented by regulation and came into force for 1990, triggering construction of an acid plant at the end of the 80's. Current emissions are around 165,000 tonnes/y SO_2. Québec has also established a particulate emission standard of 50 mg/m^3 for ventilation

sources associated with concentrate handling. Certificates of authorization are required for installation of controls on air emissions (such as baghouses, etc.). The air quality regulations are under review and may be amended to further limit SO_2 emissions to levels consistent with Noranda's public commitments. The smelter has committed to limit SO_2 emissions to 30% of the sulphur input and particulate emissions to 1.2 kg/t (feed basis) by 1998 and to reduce those emissions to 10% of input sulphur and 0.4 kg/t (feed basis), respectively, by 2002.

Québec has also established ambient SO_2 air quality standards for hourly, daily and annual averaging periods. The current standard for the hourly mean concentration is 0.50 ppm. The regulation under review would reduce the standard to 0.34 ppm but would allow for exceedances of not more than 0.20% of the total sampling hours provided that the concentration does not exceed 0.50 ppm.

The smelter effluent is subject to the general prohibition of deposits of deleterious substances in Subsection 36(3) of the *Fisheries Act*. Liquid effluents are controlled by the Quebec Ministry of Environment and Wildlife through Directive 019. A separate certificate of authorization covers the liquid effluent from the tailings pond, which receives treated water from the weak acid treatment plant.

Noranda accepted the ARET challenge in 1994 and submitted an action plan that detailed specific goals for each substance. Noranda's goals were reviewed and updated in mid-1996 and reported to ARET.

Monitoring and Research

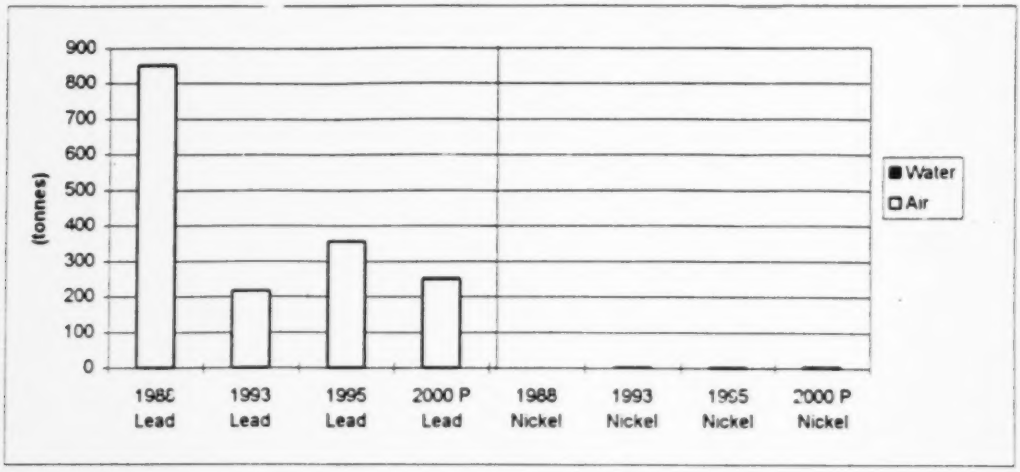
The ambient air sampling network includes seven continuous SO_2 monitors, linked to the Intermittent Control System (I.C.S.). Introduced in 1971, the I.C.S. is operated by meteorologists and technicians for predictive control of sulphur dioxide concentrations in ambient air at ground level. Specialized scientific instruments are used to determine atmospheric conditions and stability, which affect gaseous distribution. These parameters are used to develop local meteorological forecasts and to predict future air quality. Weather conditions effectively determine the allowable SO_2 emission rate to the atmosphere and smelter production levels. An environmental policy clearly indicates the full commitment of smelter operations to comply with instructions from I.C.S. staff concerning smelter production levels and SO_2 emissions. Actual observations recorded at the SO_2 monitors confirm that the ambient air standards are not exceeded and can also be used to refine the predictive model. In the event of an exceedance, I.C.S. staff provide instructions to further reduce SO_2 emission rates.

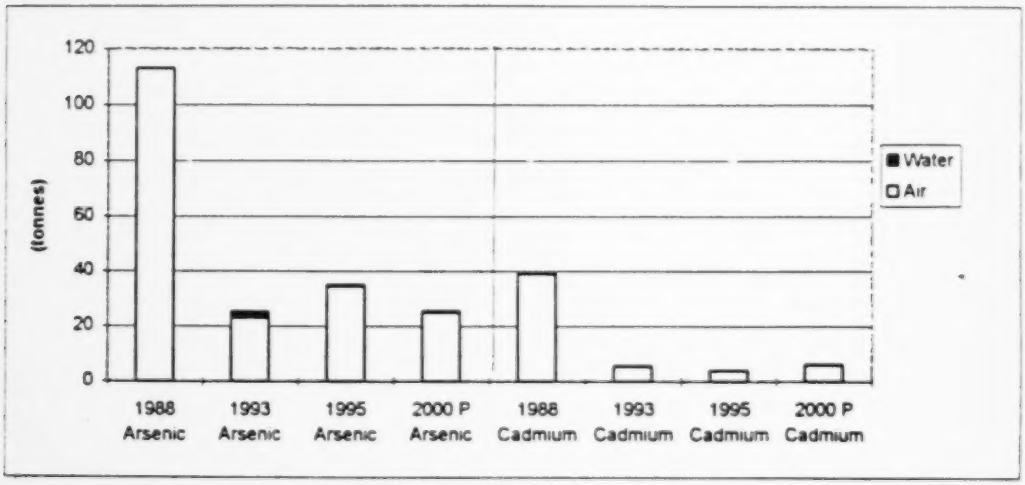
The ICS was modernized and installed in a new building at the restored and revegetated Chadbourne mine site in 1990 at a cost of $1.3 million, where it provides staff with a clear view of operations, plume movement and direction in addition to continuous surveillance of ambient SO_2 concentrations.

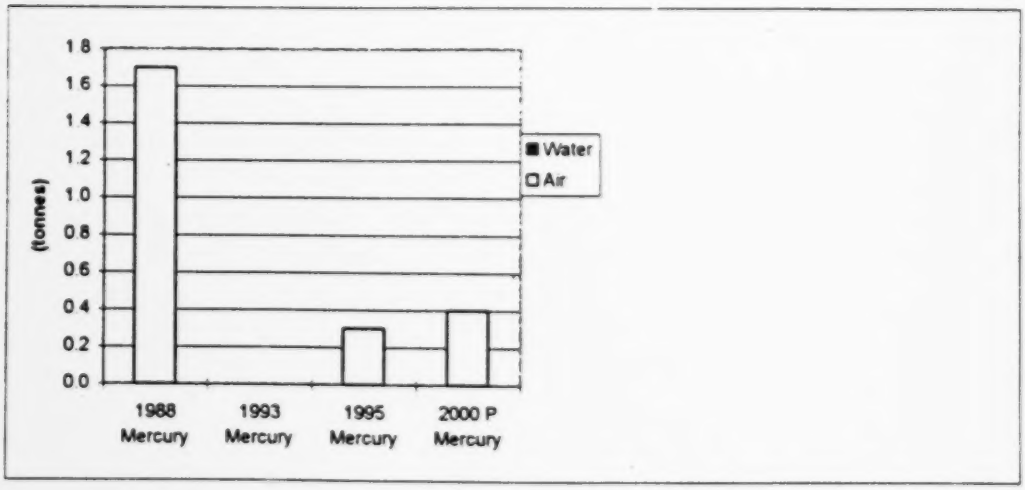
Table A6.10.2 **Releases to Air and Water and Off-site Transfers by Noranda Horne, Rouyn-Noranda, Quebec (tonnes) (Cu Smelter)**

Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	113.0	23.0	34.5	25.0
Water Releases		2.4	0.6	0.7
Total Releases	113.0	25.4	35.1	25.7
Transfers Off-site		0.0	0.0	0.0
Cadmium				
Air Releases	39.0	5.4	3.9	6.0
Water Releases	0.4	0.1	0.1	0.1
Total Releases	39.4	5.5	4.0	6.1
Transfers Off-site		0.0	0.0	0.0
Lead				
Air Releases	850.0	215.7	355.0	250.0
Water Releases	1.4	1.1	0.6	1.0
Total Releases	851.4	216.8	355.6	251.0
Transfers Off-site		0.0	0.0	0.0
Mercury				
Air Releases	1.70	0.00	0.30	0.40
Water Releases	0.00	0.00	0.00	0.00
Total Releases	1.70	0.00	0.30	0.40
Transfers Off-site		0.00	0.00	0.00
Nickel				
Air Releases	0.0	0.7	1.5	3.0
Water Releases		1.1	0.6	0.7
Total Releases	0.0	1.8	2.1	3.7
Transfers Off-site		0.0	0.0	0.0

Figure A6.10.2 Noranda Horne Releases to Air and Water







Dust-falls and high volume samplers are operated for particulate monitoring.

During the period 1991 to 1993, the smelter participated in a pilot project with the Québec - MEF for evaluation of the Programme réduction des rejets industriels (P.R.R.I.) (Industrial Waste Reduction Program). In depth characterisation was performed for process emissions to air and water at a cost of approximately $250,000.

The Centre de technologie Noranda sampled water and sediment quality in various lakes around Rouyn-Noranda at the end of 1994. Comparison with the results of previous studies shows general improvements in water quality, while metal concentration in sediments stayed at the same level. Recent release reductions are not apparent in sediments due to the slow rate of deposition of new sediments.

Programs and Plans

1984 Constructed facilities to receive, sample and prepare recyclable materials for processing at a cost of $X million.

1987-89 Shut down last reverberatory furnace and commissioned sulphuric acid plant at a cost of $160 million, achieving reductions in particulate and SO_2 emissions in excess of 50% for 1990 compared to 1980.

1990 Commissioned systems for concentrate drying and injection to the converters to replace lost production capacity at a cost of $15 million.

1990-1996 Unused sections of the plant were demolished and a program of gradual revegetation with grasses and trees was implemented around the smelter. Demolition of Stack No. 3 was completed in 1993 at a cost of $750,000. Annual costs are approximately $500,000 for demolition and $200,000 for revegetation.

1991 Developed technical options for further reductions in SO_2 and particulate emissions.

Publicly committed to further reduce SO_2 emissions (aiming at 90% reduction compared to 1980).

1991-92 Worked in partnership with representatives of the community, *ministère de l'Environnement et de la Faune*, municipality and regional health services centre to initiate and complete a community program for removal of lead-contaminated soil from the Quartier Notre-Dame, a residential area adjacent to the smelter. Close to 650 lots were remedied by replacing top soil and lawns at a cost of $3.1 million.

1992-93 Developed, pilot tested and implemented Peirce-Smith converter modifications at a cost of $10 million.

1994 Constructed major in-door copper concentrate storage area at a cost of $6 million.

Commissioned mercury removal towers in the gas cleaning section of the acid plant at a cost of $2 million.

1994-95 Developed conceptual design of a new pyro-metallurgical vessel at a cost of $1.9 million to reduce Peirce-Smith converter SO_2 and particulate emissions by processing reactor matte and directing off-gases to the existing acid plant.

1996 Commenced Noranda Reactor building expansion and construction of a Noranda converter to replace existing Peirce-Smith converter technology at a cost of $53.3 million.

1997 Baghouse installation for particulate removal from secondary ventilation gases from the tapholes of the Noranda Reactor and future Noranda Converter at a cost of $2.9 million.

Noranda Environmental Awareness Training (NEAT) Program to be offered to all employees at the Horne smelter, focused on personal responsibility for environmental compliance and performance improvement.

1997-98 Commissioning of the Noranda Converter to initially process 40% of reactor matte, with the remainder being treated by the Peirce-Smith converter. One or two Peirce-Smith converters will be modified as refining furnaces to complete sulphur oxidation prior to the anode furnace. Sulphur fixation is expected to exceed 70%.

1998-2001 Adaptation of operations to the new process, with Noranda Converter throughput increasing to 100% of reactor matte. Expansion of some sections of the sulphuric acid plant to process all reactor and converter off-gases at a cost of $50 million. Sulphur fixation is expected to exceed 90% by 2002.

Issues

Commissioning of the Noranda Converter entails substantial technical and financial risks, since new metallurgical principles will be applied in this vessel. This proprietary technology was developed by Noranda and the Horne installation will be the first commercial application.

Custom smelting brings uncertainty in the long term supply of feed materials. A successful custom smelter must have the capability to efficiently process feeds of varying quality while maintaining consistent product quality and competitive operating costs and concentrate treatment charges.

Capital resources will be scarce within Noranda Metallurgy Inc. for the next several years as major investments are foreseen at the Horne, C.C.R. and C.E.Z. and for potential development of the Magnola project to recover magnesium from asbestos residues.

Technical Options to Achieve Further Release Reductions

An Environment Canada report for the Acidifying Emissions Task Group characterizes the Horne as a large size copper smelter with an acid plant. From a national perspective, SO_2 emissions remain major at this site in spite of substantial reductions to date. Noranda's current plans will increase the capture of SO_2 to 90% and will also achieve further reductions in metal emissions. When those plans have been implemented, the facility will employ current state-of-the-art process and pollution control technology and management practices and will have no significant uncontrolled sources of metal releases. Further incremental release reductions beyond the year 2002 could be achievable with continual improvement.

6.11 NORANDA METALLURGY INC. DIVISION CEZ VALLEYFIELD, QUÉBEC

Profile

Noranda Metallurgy Inc., Division CEZ operates a zinc refinery at Valleyfield, Québec. Canadian Electrolytic Zinc Limited was established by five Canadian mining companies to process zinc concentrates produced by several mine-mill complexes in Ontario and Québec. The plant was commissioned in 1963 and became wholly-owned by Noranda during 1996. The refinery processes zinc concentrates produced by several divisions of Noranda Mining and Exploration Inc. and custom and toll zinc concentrates from a variety of sources, producing refined zinc, cadmium, copper cake and sulphuric acid. Selected production data for the period 1988 to 1995 are presented in Table A6.11.1, which includes projected levels for the year 2000.

Table A6.11.1 Production Summary (tonnes)

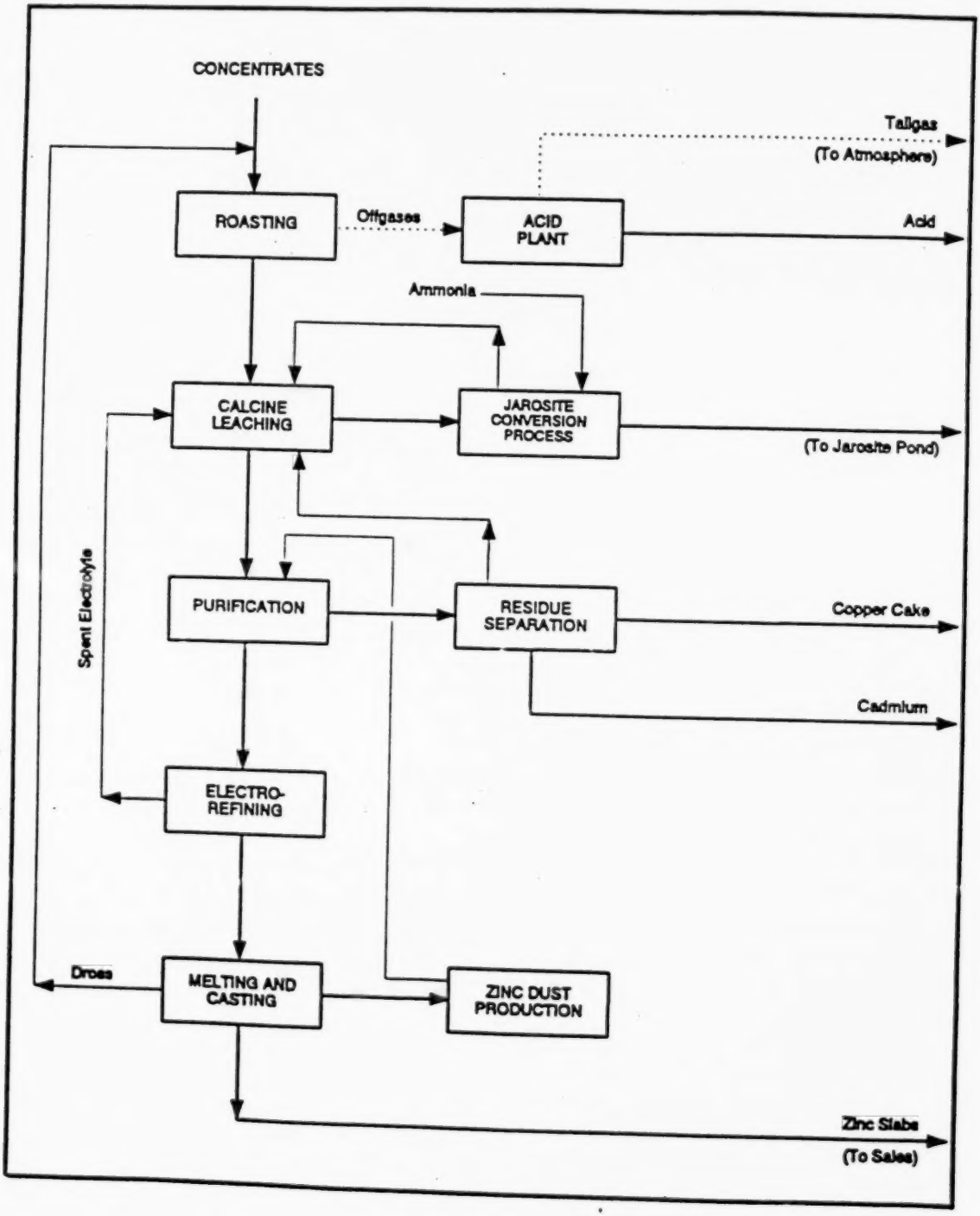
Products	1988	1993	1995	2000 (Projected)
Zinc	219,100	219,000	223,000	250,000
Sulphuric acid	409,900	395,800	388,200	426,000
Cadmium	494	297	378	355
Copper cake	3,337	3,608	3,500	3,600

Process Description

The process is outlined in Figure A6.11.1. Zinc concentrates are first processed in fluidized bed roasters where sulphide sulphur is oxidized to sulphur dioxide and zinc sulphide minerals to zinc oxides while the iron sulphide minerals are converted to zinc ferrites, $ZnO{\cdot}Fe_2O_3$. Roaster off-gases are treated in turn by a waste heat boiler, electrostatic precipitator and venturi scrubber before being directed to a sulphuric acid plant for recovery of sulphur dioxide. The scrubber produces a weak acid which is neutralized with lime to precipitate gypsum and metal hydroxides and transferred to an on-site area for impoundment as a mining residue.

The zinc calcine from the roasters is leached with sulphuric acid in three stages to extract zinc and other metals. In the first two stages, zinc oxides are selectively leached while zinc ferrites are not. In the third stage, the leach residue is subjected to higher temperatures and free acid concentrations to extract zinc from the more refractory zinc ferrites, resulting in dissolution of iron as well as zinc. Iron is removed from solution with ammonia as ammonium jarosite, which is impounded on-site as a mining residue.

Figure A6.11.1 Noranda CEZ Zinc Plant Process Flow Sheet



The leach liquor contains zinc sulphate and impurities that must be removed before zinc can be electrowon from solution. Solution purification is achieved primarily by adding zinc dust to cement out impurities. Minor amounts of antimony trioxide and arsenic trioxide are also used to control cobalt levels. The resulting purification residue is further processed to produce copper cake and metallic cadmium for sale. Zinc is then recovered by electrowinning from the purified zinc sulphate solution, and the spent electrolyte is reused in the leaching section. Zinc cathodes are mechanically stripped, melted and cast into slabs for shipment to customers. Some molten zinc is atomized to produce zinc dust for use in solution purification.

Releases

Point sources of releases to air and water from the refinery are shown in Figure A6.11.1 and controlled as outlined above.

Process gases from the roaster are treated by a recovery boiler, electrostatic precipitator and venturi scrubber for particulate control before being sent to an acid plant for recovery of sulphur dioxide. The scrubber produces a weak acid which is treated for mercury removal and neutralized. The resulting mercury-selenium sludge is disposed of off-site. These controls maintain buildings under negative pressure and minimize fugitive emissions from process equipment. All conveyors are fully enclosed to reduce fugitive emissions.

All subsequent processing other than cathode melting, casting and atomization uses hydrometallurgical methods. Antimony and arsenic additions for solution purification are added to ventilated tanks under closely controlled conditions. The electrowinning area is also well ventilated to control hydrogen and worker exposure to acid mists. The water balance for the site is closely controlled to avoid production of weak zinc sulphate solutions. All liquid effluent from the smelter site is collected, treated by lime neutralization to precipitate and remove gypsum and metal hydroxides and monitored.

Selected release data for the period 1988 to 1995 are presented in Table A6.11.2 and in Figure A6.11.2 and projected levels for the year 2000 are included. Releases of *CEPA* substances decreased by over 58% from 1988 to 1995 and further release reductions are projected.

Regulatory and Non-Regulatory Programs

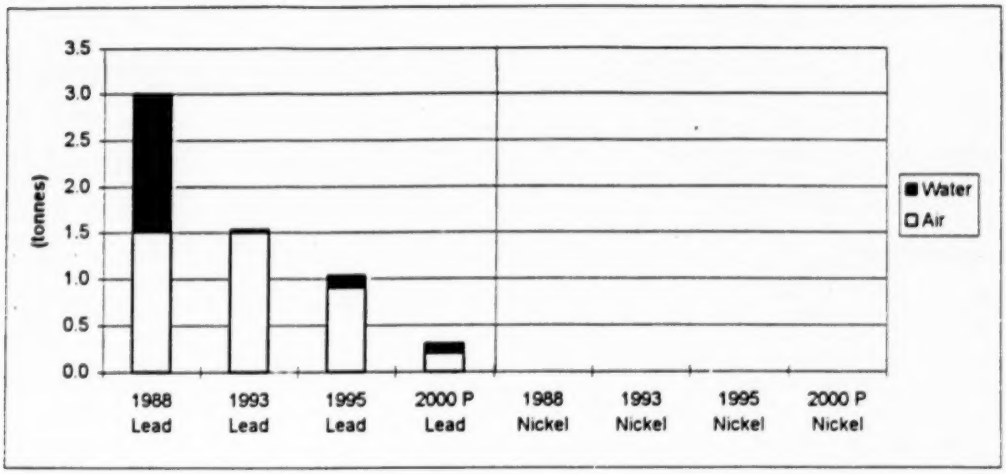
The zinc refinery is regulated by Québec, which has established a particulate emission standard of 50 mg/m^3. Québec has also established ambient SO_2 air quality standards for hourly, daily and annual averaging periods. The current standard for the hourly mean concentration is 0.50 ppm. The regulation under review would reduce the standard to 0.34 ppm but would allow for exceedances of not more than 0.20% of the total sampling hours provided that the concentration does not exceed 0.50 ppm.

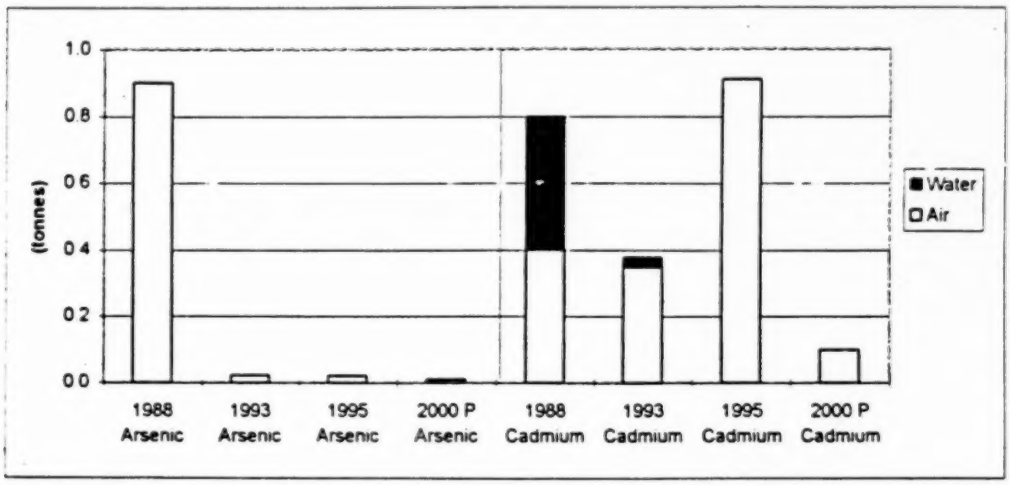
Table A6.11.2 Releases to Air and Water and Off-site Transfers by Noranda CEZ, Valleyfield, Quebec (tonnes) (Zinc Plant)

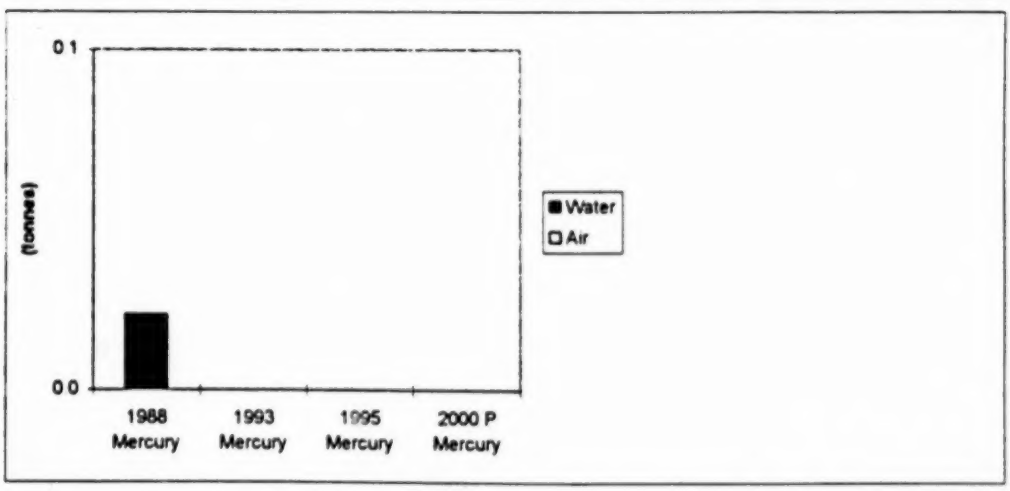
Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	0.9	0.0	0.0	0.0
Water Releases		0.0	0.0	0.0
Total Releases	0.9	0.0	0.0	0.0
Transfers Off-site		0.0	0.0	0.0
Cadmium				
Air Releases	0.4	0.3	0.9	0.1
Water Releases	0.4	0.0	0.0	0.0
Total Releases	0.8	0.4	0.9	0.1
Transfers Off-site		0.0	0.0	0.0
Lead				
Air Releases	1.5	1.5	0.9	0.2
Water Releases	1.5	0.0	0.1	0.1
Total Releases	3.0	1.5	1.0	0.3
Transfers Off-site		0.0	8.0	0.0
Mercury				
Air Releases	0.00			
Water Releases	0.02			
Total Releases	0.02			
Transfers Off-site		0.00	10.00	2.00
Nickel				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				

In 1995 several years accumulation of mercury wastes were shipped. to an off-site waste disposal site.

Figure A6.11.2 Noranda CEZ Releases to Air and Water







The site effluent is subject to the general prohibition of deposits of deleterious substances in Subsection 36(3) of the *Fisheries Act*. Mining liquid effluent are also regulated by Québec under Directive 019, which establishes standards for similar parameters at levels similar to those in the federal *Metal Mining Liquid Effluent Regulations* and the associated *Guidelines for the Control of Liquid Effluents from Existing Metal Mines*.

The facility is one of 106 industrial plants designated under St. Lawrence Vision 2000, the second phase of the St. Lawrence Action Plan, launched in 1988. The overall objective is to reduce liquid toxic waste and virtually eliminate discharges of persistent toxic substances. The facility is part of Group 4, comprising the 50 plants targeted under the St. Lawrence Action Plan. The objective set for Group 4 is to pursue cleanup efforts and perform environmental monitoring to achieve a 90% reduction in liquid toxic waste.

Noranda accepted the ARET challenge in 1994 and submitted an action plan that detailed specific goals for each substance. Noranda's goals were reviewed and updated in mid-1996 and reported to ARET. Noranda is a member of the Canadian Chemical Producers Association and the refinery's sulphuric acid plants and distribution are subject to that association's Responsible Care® program.

Monitoring and Research

The refinery's site-specific monitoring program is oriented primarily towards the most significant environmental aspects of SO_2 and liquid effluent releases and environmental impacts. Data is also collected to characterize air emissions of particulate matter and metals and ambient environmental conditions.

A continuous SO_2 monitor is installed in the tailgas stack from one of the three acid plants. The performance of the other two acid plants is monitored by performing Reich tests every two hours to verify the continued effectiveness of conversion of SO_2 to SO_3 prior to absorption. Two additional monitors will be installed during 1997 to provide continuous SO_2 emission monitoring of all three acid plants. Source monitoring is supplemented by continuous monitoring of ambient air quality at two locations. Noranda supported a graduate student project to develop, calibrate and validate a local atmospheric dispersion model of the refinery using plant data.

Stack sampling is conducted as required to characterize air emissions of particulate matter and metals or to calibrate continuous monitors. The results are used to identify release reduction opportunities and to establish priorities. Sampling will be repeated to confirm the effectiveness of new controls to be installed in 1997. Ambient environmental conditions are also monitored by high volume air sampling at one or two locations and dustfall monitoring at ten stations.

Regular monitoring of the effluent treatment plant and cooling water discharges is conducted to characterize point discharges of metals to the receiving water and the toxicity of refinery effluents. A network of over 70 wells is sampled annually to monitor potential effects on groundwater quality and any resulting non-point discharges from the site. Regular monitoring of impoundment structures is performed by a geotechnical consultant to ensure the stability of those structures and avoid unplanned releases to the environment.

The liquid effluent was characterized for the SLV 2000 in 1991. Eight substances were detected in testing for more than 120. The SLV 2000 uses the Chimiotox index to assess the contribution of all toxic substances to effluent toxicity, applying a toxicity factor determined for each substance. The 1991 data indicated that selenium accounted for 64% of the Chimiotox index, followed by copper (14%), cadmium (12%) and zinc (8%). The SLV 2000 reported that the Chimiotox index value was reduced by 61% between 1988 and 1995, while liquid effluent discharges of cadmium, zinc and ammonia nitrogen were reduced by 88%, 93% and 68%, respectively. The planned introduction of selenium elimination systems during 1997 will further lower the Chimiotox index. Noranda anticipates that the SLV 2000 objective for Group 4 of a 90% reduction in liquid toxic waste, as determined by the Chimiotox index, will be met or exceeded with the removal of selenium from the weak acid bleed.

The SLV 2000 also uses a Potential Ecotoxic Effects Probe, or PEEP, to combine results from six standardized bioassays measuring the toxic effects of effluent. In 1991, the PEEP value of 4.6 for the refinery was in the average range of the PEEP values found for the 50 plants.

A Community Advisory Panel was established in early 1997 to provide guidance to the refinery. The facility's environmental performance and environmental management system are periodically reviewed by an independent team of Noranda internal auditors. Sulphuric acid production and risk management programs fall within the scope of the Canadian Chemical Producers Association's Responsible Care® program and will be the subject of an independent audit during 1997.

Programs and Plans

1988	Diverted surface drainage to water treatment, reducing zinc and cadmium discharges at a cost of $250,000.
1990	Installed demisters on vacuum coolers, reducing zinc discharge at a cost of $1.1 million.
1992-96	Completed liquid effluent and site characterizations at a cost of $1.4 million.
1994-96	Completed several spill prevention and control projects at a cost of $2.9 million.

1996	Initiated engineering of gas scrubbing system for roaster start-up fan.
	Eliminated all PCBs stored at the site at a cost of $300,000.
	Restored the 12 hectare jarosite Pond 5A at a cost of $9 million, installing a cap consisting of a high density polyethylene liner and a layer of soil. Another similar pond is expected to restored by the year 2000.
	Pilot tested new process for selenium removal from weak acid bleed at a cost of $300,000.
	Pilot tested new process to produce an inert iron residue at a cost of $1.2 million.
1996-97	Complete 8 hour environmental training program for all 750 employees at a cost of approximately $200,000.
1997	Install gas scrubbers for roaster start-up fan and calcine addition system at a cost of $3 million.
	Install selenium removal treatment plant at a cost of $2 million.
1998	Implementation of new process for iron residue management at a cost of $28 million.
	Anticipated replacement of effluent treatment plant at a cost of $9 million.

Issues

Security of zinc concentrate supply with declining domestic production.

Need for continued improvements to maintain or improve competitive position and generate cash to fund new investment.

Prioritization of health and environmental risk reduction opportunities.

Technical Options to Achieve Further Release Reductions

An Environment Canada report for the Acidifying Emissions Task Group notes that, from a national perspective, SO_2 emissions are low at this site and further reductions would have little effect on the larger national picture. Planned improvements underway will result in SO_2 reductions that will contribute to improved local air quality. The last recorded exceedance of the ambient air quality standard in the vicinity of the facility was in 1990.

The facility employs current state-of-the-art pollution control technology and management practices and has no significant uncontrolled sources of metal releases. Incremental release reductions may be achievable with continual improvement. A major investment in currently available process technology would not substantially reduce metal releases.

6.12 NORANDA METALLURGY INC. DIVISION CCR MONTRÉAL-EST, QUÉBEC

Profile

Noranda Metallurgy Inc., Division CCR operates a copper refinery in Montréal-Est, Québec. The plant commenced production in 1931 to process copper anodes produced by the associated Horne smelter. The refinery now processes copper anodes produced by Noranda's smelters at Rouyn-Noranda and Murdochville, Québec and from purchased copper scrap and blister cakes, producing high purity cathode copper, copper sulphate, nickel sulphate, gold, silver and platinum/palladium concentrate, selenium and tellurium. Selected production data for the period 1988 to 1995 are presented in Table A6.12.1, which includes projected levels for the year 2000.

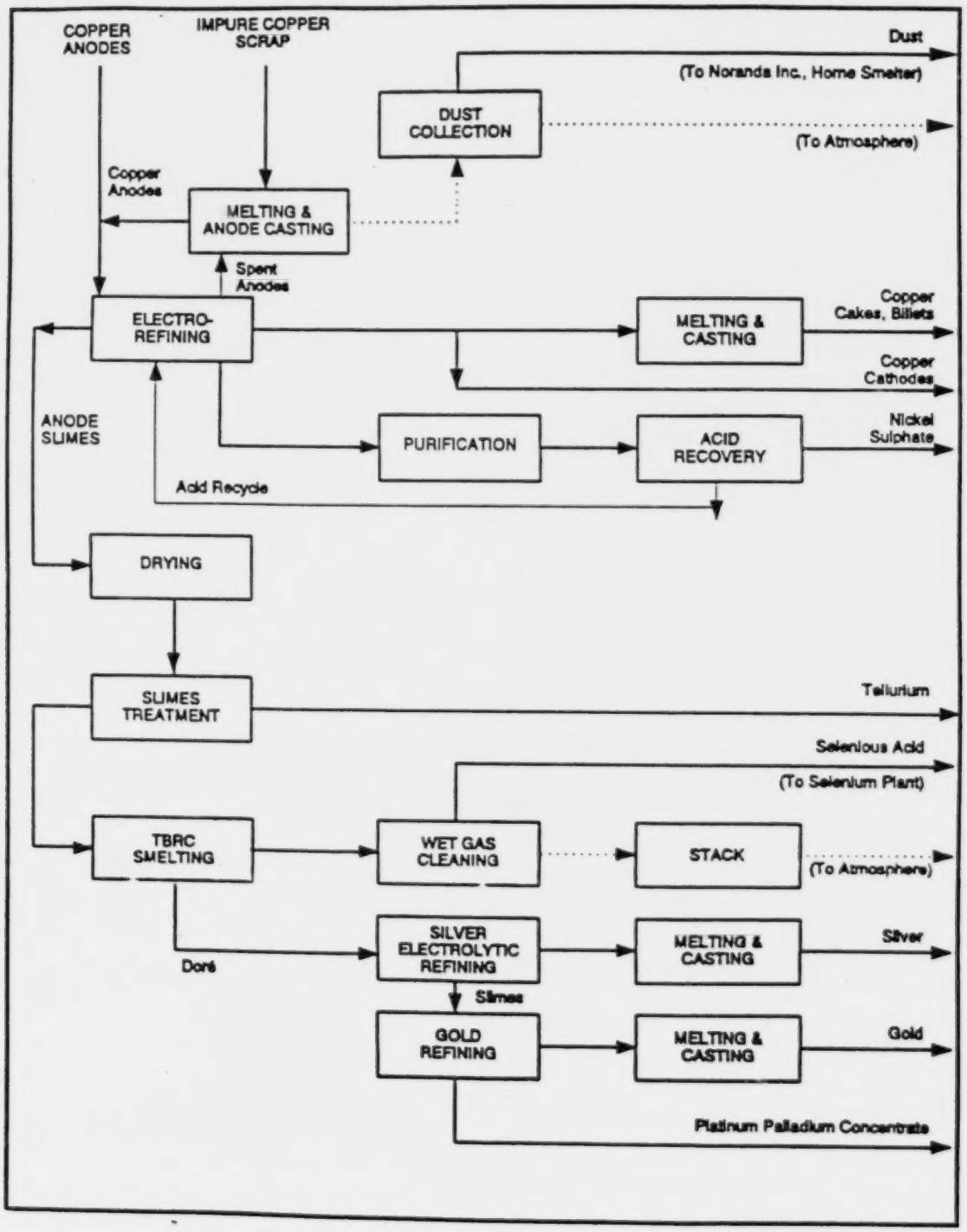
Table A6.12.1 Production Summary (tonnes)

Products	1988	1993	1995	2000 (Projected)
Copper cathodes	349,768	345,753	347,173	350,000
Copper sulphate	7,406	6,121	5,668	5,500
Nickel sulphate	892	1,479	1,592	1,500
Silver bullion	811	820	800	800
Gold bullion	26	35	28.9	30
Selenium	500	568	410	500
Tellurium	10	12.9	30	20
Platinum/palladium conc	3.8	6.7	4.2	6

Process Description

The process is outlined in Figure A6.12.1. The refinery removes very small quantities of metal impurities from feed materials to produce high purity copper and other products. Most of the copper anodes to be refined are received from Noranda's copper smelters at Rouyn-Noranda and Murdochville. Anodes are also produced from scrap purchased by the refinery and may be purchased from other copper producers or refined on a toll basis.

Figure A6.12.1 Noranda CCR Copper Refinery Process Flow Sheet



Anodes are refined by an electrolytic process. Sulphuric acid is used as the electrolyte and direct current is applied to dissolve copper at the anode. Impurities including precious and platinum group metals are distributed between the electrolyte and the anode slimes. The copper cathode product is plated onto copper starting sheets. Electrolyte is continuously withdrawn for removal of nickel sulphate and other impurities such as arsenic, bismuth and antimony. The nickel sulfate is sold, the recovered sulphuric acid is re-used to the tankhouse and the impurities are recycled back to the smelters. Spent anodes are removed from the cells after 21 days while approximately half of the cathodes are removed from the cell every 10 or 11 days. A significant portion of the anode is not dissolved. Spent anodes are remelted and cast into new anodes for reprocessing. Off-gases from melting and anode casting are treated by a baghouse prior to release to the atmosphere. Baghouse dust is returned to the Horne smelter for recycling.

Some of the cathodes produced are melted and cast into copper billets or other shapes for the market, while most are sold directly. Off-gases from cathode melting and casting are not treated prior to release to the atmosphere.

Anode slimes are washed from the spent anodes and removed from the cells for further processing to recover precious, platinum group and specialty metals. The slimes are first treated to remove tellurium and copper and then smelted in a Top Blown Rotary Converter (TBRC). Solutions from the tellurium recovery stage are further processed to produce metallic tellurium and copper sulphate. The TBRC produces Doré anodes which are further refined to produce metallic silver, gold and a platinum-palladium concentrate. TBRC slags are milled and floated to recover a precious metals concentrate while the tailings are recycled to the Horne smelter. Off-gases from the TBRC are treated by wet scrubbing to remove dust and fume containing volatile metals and metal oxides. Fugitive emissions from the TBRC operation are collected in an enclosure and treated by a baghouse prior to release to the atmosphere. Slag handling prior to milling is carried out in an area ventilated by a separate baghouse.

The gold refining process is connected to a wet scrubber for sulphur dioxide capture and the silver refining process has a water absorption tower for NO_x particulate capture. The selenium processing plant uses baghouse, cartridge filter and wet scrubbing technologies to control emissions.

All process liquid effluents from the site are treated by an effluent treatment plant prior to discharge to the municipal sewer system.

Releases

Point sources of releases to air and water from the smelter are shown in Figure A6.12.1 and controlled as outlined above.

Dry gases from melting and casting of copper anodes are treated by a baghouse prior to release to the atmosphere. Baghouse dust is returned to the Horne smelter for recycling.

Wet process gases from the TBRC, gold refining, silver refining and selenium processing are processed by separate wet scrubbing systems. The resulting sludge is recycled to the TBRC.

Fugitive emissions from the TBRC are recovered by a baghouse and returned to the TBRC to minimize fugitive emissions from process equipment.

All liquid process effluents from the refinery are collected, pretreated for precious metals control when required, then sent to the waste water treatment plant before discharge to the sewer. Approximately 20% of the total effluent volume from the site is treated. The remaining volume consists of non-contact cooling waters, sewage and other waters that are not contaminated by metals.

Selected release data for the period 1988 to 1995 are presented in Table A6.12.2 and in Figure A6.12.2 and projected levels for the year 2000 are included. Releases of *CEPA* substances decreased by over 91% from 1988 to 1995.

Regulatory and Non-Regulatory Programs

The copper refinery is regulated for air and water emissions by Québec through the Communauté Urbaine de Montréal (CUM).

The refinery effluent is treated prior to being discharged to the Durocher main sewer. This sewer was connected to the CUM wastewater treatment plant in 1994. The effluent is subject to CUM by-law 87 governing the discharge of wastewater into sewers and waterways and complies with all the by-law's discharge criteria.

Limits for emissions to air are prescribed by CUM by-law 90. All but one emission sources are in compliance. A project aimed at achieving full compliance is now pending budgetary approval.

The facility is one of 106 industrial plants designated under St. Lawrence Vision 2000, the second phase of the St. Lawrence Action Plan, launched in 1988. The overall objective is to reduce liquid toxic waste and virtually eliminate discharges of persistent toxic substances. The facility is part of Group 4, comprising the 50 plants targeted under the St. Lawrence Action Plan. The objective set for Group 4 is to pursue cleanup efforts and perform environmental monitoring to achieve a 90% reduction in liquid toxic waste.

Noranda accepted the ARET challenge in 1994 and submitted an action plan that detailed specific goals for each substance. Noranda's goals were reviewed and updated in mid-1996 and reported to ARET. Noranda is a member of the Canadian Chemical Producers Association and the refinery's sulphuric acid plants and distribution are subject to that association's Responsible Care® program.

Monitoring and Research

The liquid effluent was characterized for the SLV 2000 in 1991. Eleven substances were detected in testing for more than 120. The SLV 2000 uses the Chimiotox index to assess the contribution of all toxic substances to effluent toxicity, applying a toxicity factor determined for each substance. The 1991 data indicated that arsenic accounted for 83% of the Chimiotox index, while no other CEPA toxic substance accounted for >1% of the index. The SLV 2000 reported that the Chimiotox index value was reduced by 99% between 1988 and 1995, while liquid effluent discharges of arsenic, cadmium and lead were reduced by 99%, 67% and 89%, respectively.

The SLV 2000 also uses a Potential Ecotoxic Effects Probe, or PEEP, to combine results from six standardized bioassays measuring the toxic effects of effluent. In 1991, the PEEP value of 3.3 for the refinery was one of the lowest PEEP values found for the 50 plants.

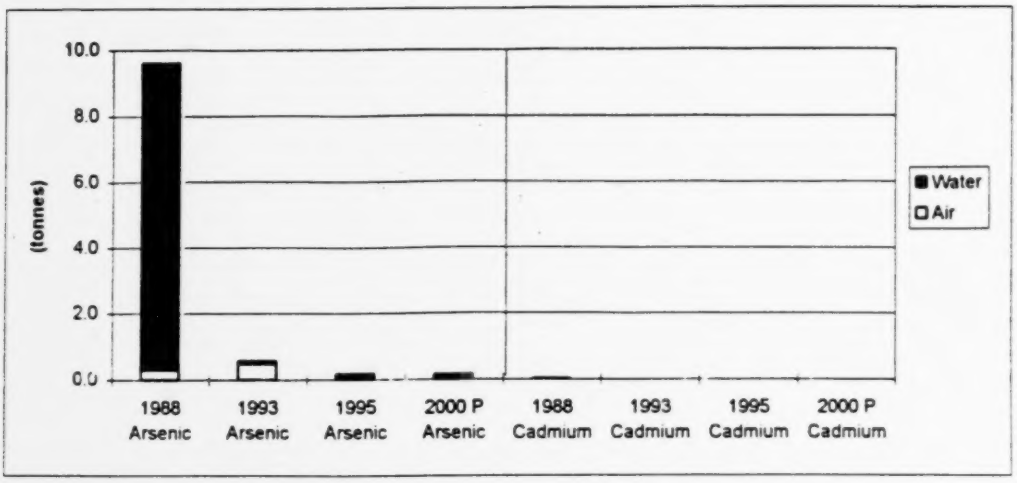
Programs and Plans

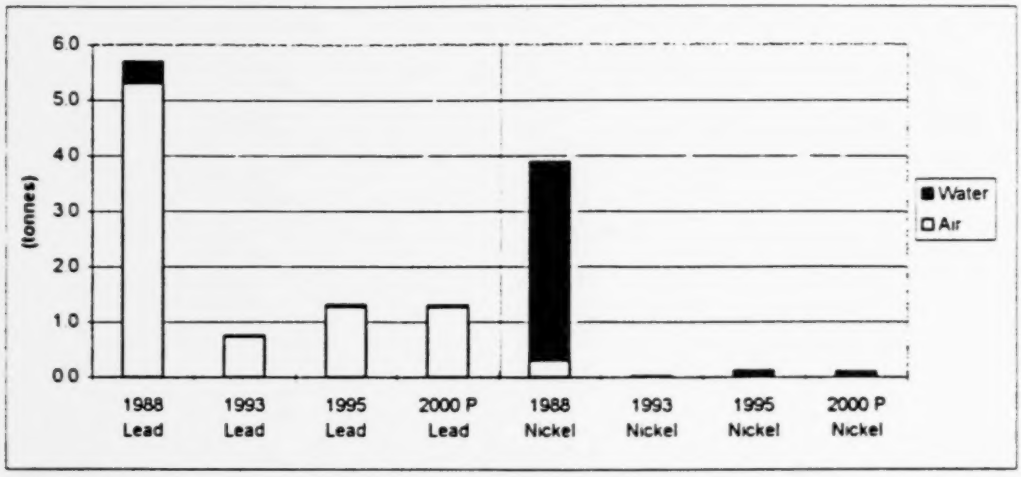
1988	Commissioned Top Blown Rotary Converter (TBRC) at a cost of $21 million, reducing air emissions of arsenic, lead and nickel by 67%, 75% and 90%, respectively.
1989	Commissioned new effluent treatment plant as part of a $12.5 million project, reducing liquid effluent discharges of arsenic, cadmium, lead and nickel.
1994	Commissioned a new production process for silver nitrate at a cost of $450,000, eliminating use of sodium hydroxide and discharge of sodium nitrate to the sewer.
1995	Installed safety cartridge filters at the selenium refinery as an added measure aimed at reducing selenium emissions.
1996	Achieved ISO 9002 certification.

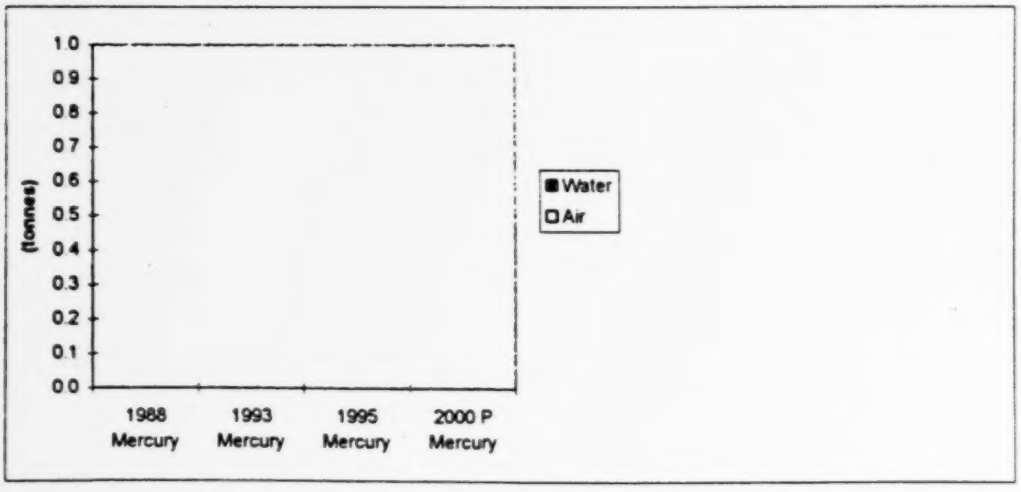
Table A6.12.2 **Releases to Air and Water and Off-site Transfers by Noranda CCR, Montreal East, Quebec (tonnes) (Cu Refinery)**

Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	0.3	0.5	0.1	0.1
Water Releases	9.3	0.1	0.1	0.1
Total Releases	9.6	0.6	0.2	0.2
Transfers Off-site		9.2	8.9	6.2
Cadmium				
Air Releases	0.0	0.0	0.0	0.0
Water Releases	0.0	0.0	0.0	0.0
Total Releases	0.0	0.0	0.0	0.0
Transfers Off-site		0.0	0.0	0.0
Lead				
Air Releases	5.3	0.7	1.3	1.3
Water Releases	0.4	0.0	0.0	0.0
Total Releases	5.7	0.8	1.3	1.3
Transfers Off-site		0.3	0.5	0.4
Mercury				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Nickel				
Air Releases	0.3	0.0	0.0	0.0
Water Releases	3.6	0.0	0.1	0.1
Total Releases	3.9	0.0	0.1	0.1
Transfers Off-site		0.2	1.6	1.2

Figure A6.12.2 Noranda CCR Releases to Air and Water







Issues

The site is participating on a voluntary basis with Environment Canada, the Port of Montreal, Shell Canada and Imperial Oil on a project to identify possible decontamination measures to restore full use of Wharf 103. Sediments and the bottom of the wharf have been found to be contaminated with organic matter and heavy metals.

Technical Options to Achieve Further Release Reductions

The facility employs current state-of-the-art process and pollution control technology. Further release reductions may be achievable through continual improvement.

6.13 NOVA Pb INC.
VILLE STE-CATHERINE, QUÉBEC

Profile

The Nova Pb Inc. secondary lead smelter is located on a 50 acre site in an industrial park in Ville Ste-Catherine, a south shore suburb of Montreal. Nova Pb is Canada's largest integrated lead recycling facility with a capacity to produce in excess of 50,000 tonnes of lead per year. 'Nova Pb" brand lead is a London Metal Exchange approved and traded brand, sold throughout the international marketplace. Nova Pb refines over 40 different specifications of lead alloys each having its own individual elemental composition certified on a parts per million basis by Nova Pb 's ISO/CEI 25 (IS09000) certified laboratory. Table A6.13.1 indicates Nova Pb's refined, lead output from 15,600 metric tonnes in 1985 to a projected 80,000 metric tonnes by year 2000.

Table A6.13.1 Production Summary (tonnes)

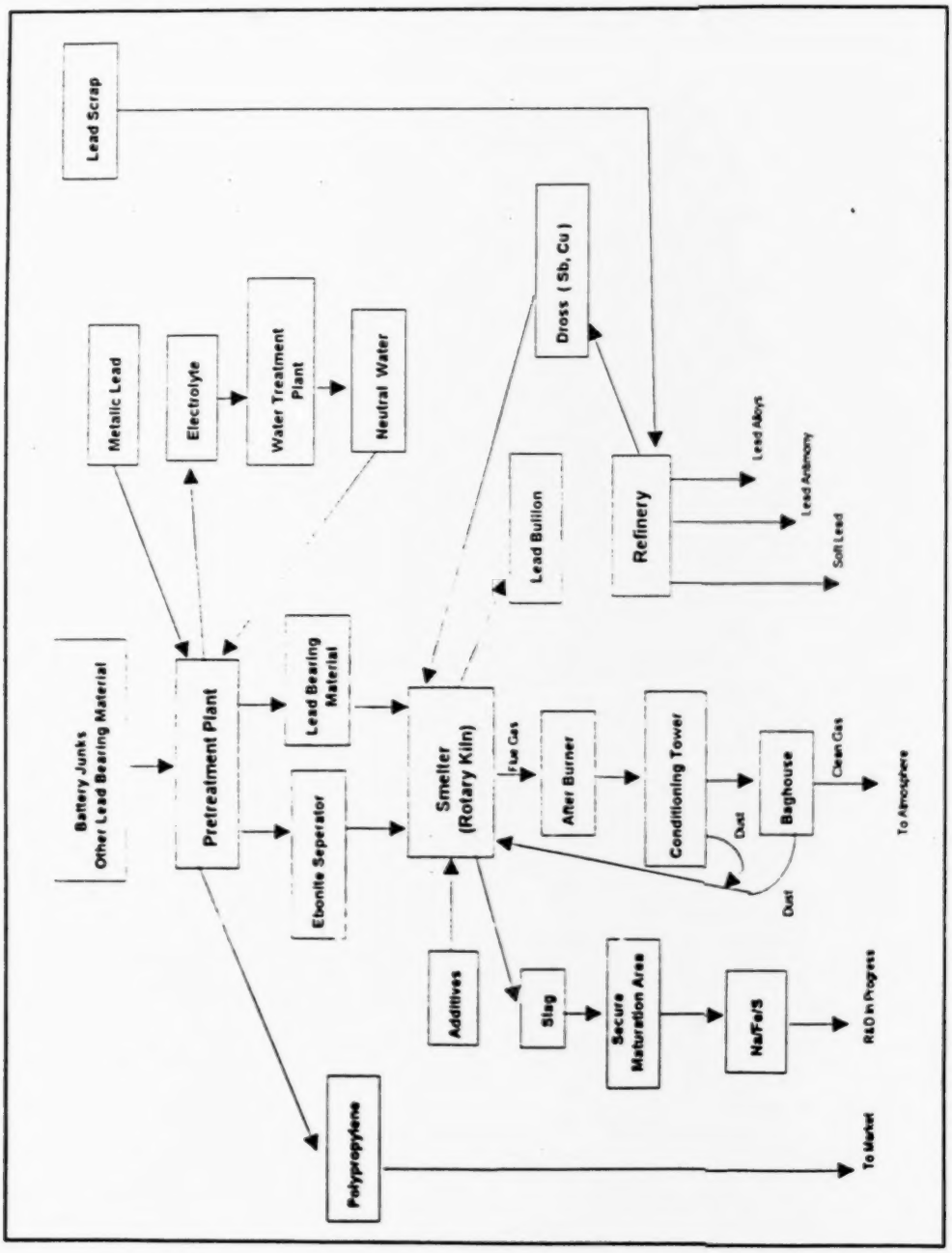
Product	1985	1990	1995	2000
Refined Lead	15,600	35,850	46,900	80,000

The plant and facilities were originally built by Preussag AG of Hanover, West Germany in 1980, at a cost of over of $40 million (Cdn). Today, the replacement value of the current operations is well in excess if $100 million (Cdn) and approximately one half of all capital investment is environmental control related. The operation was purchased from Preussag by Nova Pb Inc. in 1984.

Nova Pb's Lead Recycling Process

All incoming raw materials are weighed, inspected, unloaded and segregated according to their processing destination. The first time any new non-battery raw material is received it is immediately sampled by qualified laboratory personnel. This material is then numerically identified by the incoming weigh-scale ticket and subsequently analyzed. Included with these materials to be assayed are non-lead bearing additives such as coke breeze and scrap iron borings which are required in the smelting and refining operations. Nova Pb also uses a significant amount of waste oils and every load is also analyzed and registered as per the Ministry of the Environment and Wildlife of Quebec (M.E.F.) norms.

Figure A6.13.1 Nova Pb Process Flow Sheet



After spent lead-acid batteries are unloaded, they are immediately transferred to the primary classification building, known as the Battery Classification Plant (B.C.P.). The heart of the B.C.P., a modified MA battery classification system was commissioned in the fall of 1989, designed by MA Industries of Peach Tree, Georgia, but was significantly modified by Nova Pb to comply with stringent internal requirements This equipment ensures a complete segregation of all major battery components. Once the battery is crushed, the battery paste and metallic components are stockpiled and analyzed weekly. The separators and ebonite are then gradually re-mixed with the battery paste prior to being fed to the kiln.

Finally, the multicolored polypropylene chips originating from the battery cases are processed, cleaned and analyzed on a van load basis prior to shipment to numerous recyclers. Over 99% of all the plastic from battery cases is recycled.

Although the typical raw material feed for the operation is spent lead-acid batteries, Nova Pb also processes a significant volume of hazardous lead-bearing material in such forms as dust, sludge and slag. These can originate from industrial sectors other than the battery manufacturing industry such as ammunition, pigments and glass. All of the hazardous waste in question is manifested and shipped to Nova Pb with the expressed knowledge and consent of the US EPA, Environment Canada and Ministry of the Environment and Wildlife of Quebec in accordance with the Bilateral US/Canada Agreement regulating hazardous waste.

A weekly composite assay report of material from the B.C.P., together with other assay reports of non-battery lead-bearing materials, represent the input components for the preparation of the rotary kiln raw material charge or more precisely the feed mix, This feed mix is comprised of lead bearing elements such as lead oxide (PbO_2) and lead sulfate ($PbSO_4$) to which the reagents carbon (C), iron (Fe), and soda ash (Na_2CO_3) are added.

As Figure A6.13.1 illustrates, the closed-loop rotary kiln represents a unique technology within the North America's lead industry, hence it is ideally suited to analytical process controls. Nova Pb has developed a proprietary computer software program which is used to prepare the optimum kiln feed mixes. With thorough chemical knowledge of the raw material input, Nova Pb can effectively prepare a "recipe" which maintains a perfect internal stoichiometric balance of both lead reducing additives and lead-bearing components. By entering all variables into the program, we can more precisely determine the type and quantity of additive required to maximize the lead reduction process, while also controlling the residual slag elements ensuring that it meets non-hazardous waste criteria set by Environment Canada and Ministry of the Environment and Wildlife of Quebec authorities. The residual slag captures undesired components such as sulfur in an inert and stable matrix mainly comprised of iron sulfide (FeS), sodium sulfide (Na_2S) and sodium sulfate (Na_2SO_4). The software helps in improving the kiln's bullion, thus rendering the refinery more cost effective in the final preparation of individual client specifications.

The long rotary kiln,140 feet long and 9 feet in diameter, represents the heart of the smelting process at Nova Pb Inc. Smelting temperatures can reach as high as 1,100 C (2,012 F) using a natural gas/waste oil fed burner with a capacity of 55 million BTU's or 138 kilocalories per hour. At these temperature various reactions are produced to isolate the lead, trap the sulfur and yield carbonic gas. The Nova Pb rotary kiln operates within a closed-loop air and water circuit. This ensures that all off-gases, particulate and residues are completely captured by the environmental control equipment. All dust and particulate go to one of two in-line bag houses and are automatically re-fed to the kiln as a raw material charge. At regular intervals, the process engineer takes numerous samples to monitor the operation's efficiency and environmental conformity. Monitoring of all key environmental performance criteria, such as stack testing and water treatment plant effluent, is conducted on a 24 hour per day and 7 day per week basis.

During the second quarter of 1994, Nova completed the installation of a state-of-the-art post combustion technology on it's long rotary kiln. This $2 .5 million (Cdn) investment is intended to more effectively process material from numerous waste streams. Also, this new technology will allow Nova the possibility to recover the chemical and calorific values from other products such as waste oils, oil refinery sludges and spent oil filters.

All packaging material such as drums and pallets, received at the smelter are currently shredded and fed to the kiln, providing both a source of energy and fluxing material. Since Nova Pb has its own on-site completely sealed waste storage facility, no material sent to the plant and residual contaminated waste-stream will leave the site. This fact, and the fact that Nova Pb is becoming a "zero-discharge" lead recycling facility, assures both Nova Pb suppliers and clients that their products are processed in an environmentally sound manner.

The molten leaded bullion from the rotary kiln is transferred into one of three, sixty metric ton holding kettles. After the copper dross has been removed, these individual kettles are then sampled and assayed to determine their optimal use. Bullion containing a high percentage of antimony will be used to refine a full range of antimonial-lead alloys, while bullion containing lower percentages of antimony will be refined down to a soft or corroding grade lead. Once the weekly production schedule has determined the most economical and appropriate final application, the molten bullion is re-transferred into one of eight one hundred metric ton refining kettles. Samples are taken and assayed throughout the entire refining process tracking each one hundred metric ton lot. The elaboration of the batch is done according to established procedures and recorded in the process control journal.

Once the laboratory certifies that a particular kettle meets the individual client's specifications, 2 pre-final and 3 final samples are taken, assayed and verified. Only after every element of the two pre-final analyses are within specifications, does the Quality Control group authorizes the pouring of this kettle. Each kettle, upon being

prepared with molten lead, is issued an identifying lot number which remains with this material through to the final ingot casting stage where-upon, it is automatically stamped into each individual ingot and hog. Then a corresponding Nova Certificate of Analysis is issued certifying the chemical elemental accuracy of this lot.

Once cast into 27 kilogram (60 pound) ingots called "pigs" or 1 metric ton blocks, called "hogs", the material is transferred to the finished products storage area for final preparation to our customers' specifications. This includes any additional stamping, color coding or wrapping.

Final analysis and inspection of all finished product is performed on a lot by lot basis prior to shipment. At least one lead bundle of each out-bound shipment must be initialed and stamped prior to shipment by the management personnel responsible for quality control. When requested by our clients, a small lot sample, as well as a Certificate of Analysis is sent out with every shipment, however Nova Pb retains lot samples, certificates and journals for a minimum period of one year.

A key element in the Nova corporate policy has been the uncompromising dedication to high quality products and services.

Releases

The permissible emission level is a maximum of 28.98 milligrams of lead per normal cubic meter per hr (46 x 63%). As the following table illustrates, at 2.209 milligrams of lead per normal cubic meter, Nova Pb's emissions are 7.6 % that of the Federal furnace stack norm.

Nova Pb Annual Kiln Stack Lead & Particulate Emissions per Arthur Gordon, April'95	
Total flue gas emitted (see note 1)	70,000 Normal cubic meters/hr
Particulate emissions A.G. (see note 1)	7.837 mg of dust per normal cubic meter
Lead, mg per normal cubic meter A.G. (see note 2)	2.209 mg

Note 1: Per Secondary Lead Smelter Release Regulations of Canada Gazette March 13, 1991, per 3(a) concentration of particulate not to exceed 46 mg per normal cubic meter

Note 2 Per Secondary Lead Smelter Release Regulations of Canada Gazette March 13, 1991, per 4(a) lead in particulate shall not exceed 63% by weight of the total particulate matter

With respect to effluent releases, since the installation of the post combustion technology in 1994, coupled with an increased requirement for water cooling in the casting operation, Nova Pb is discharging less and less of its treated effluent. As stated earlier, by the end of 1997 Nova Pb should be a "zero discharge" facility. However, at

the present time and only in the event of an excessive volume of surface or process rain water, the effluent is first sampled, compliance levels confirmed and the released. Based upon these samples a daily composite of lead, zinc, arsenic and pH levels are determined. Because Nova Pb discharges directly into the St. Lawrence Seaway, it is required to respect far more stringent effluent releases than normally required if it were to release water into the city's sewage system. All the results and reports are maintained and made available to Provincial regulatory authorities upon request. Actual provincial norms, a typical Nova Pb result and a counter analysis done by an outside provincially certified lab (Analex), are as follows:

Parameters	Quebec norms for Nova Pb	Base/unit	Nova Pb Results	Analex U96-27
Pb	0.2	milligrams/liter	0.16	0.14
Zn	2	milligrams/liter	0.09	0.08
As	5	milligrams/liter	0.0051	0.011
pH	>8 & <10.5		10.1	9.4

Regulatory and Non Regulatory Programs

The lead smelter and refinery are subject to the *Secondary Lead Smelter Release Regulations* under the *Canadian Environmental Protection Act,* which establishes legally enforceable limits for particulate emissions containing lead. These limits are outlined in Section 5.

Nova Pb is also subject to Quebec's Ministry of the Environment and Wildlife's Air Quality legislation *(M.EF.; Règlement sur la qualité de l'atmosphère R.R.O. Q-2 r.20).* This legislation establishes norms for ambient air and particulate emissions, vapors, gases, opacity and also establishes measures to control, eliminate and reduce contaminants originating from all sources. As stated earlier, Nova Pb's 2.209 mg of lead per normal cubic meter represents 7.6% of the Federal furnace stack norm.

It is worth noting that the Canadian Resources and Environment Ministers *(C.CM.R.E: Lignes directrices pour les incinérateurs de déchets municipaux)* proposes a limit of 100 PPM of sulfur dioxide (SO_2)for municipal incinerators. Nova Pb's $S0_2$ emissions are normally less than 1 PPM. Table A6.13.2 and Figure A6.13.2 illustrate the detail of Nova Pb's releases :

Monitoring and Research

All water discharges are analyzed by the Nova Pb provincially accredited laboratory and are periodically verified by another accredited laboratories (ex. Analex). The laboratory also routinely analyzes surrounding ground water and soil for any contamination. On-line stack sensors measure variables such as $S0_2$, $C0_2$, CO and opacity to monitor the efficiency of the operation on a 24 hr per day and 7 day per week basis.

An additional element that is vigorously monitored is the blood lead levels of all Nova Pb employees. These monthly blood tests measure lead in the employee's blood thus monitoring his lead exposure as well as the efficiency of the facility's environmental protection equipment and work methods. Government health and safety nurses (C.S.S.T.) sample the workers and forward the blood sample to their own government laboratory, hence ensuring the objectivity of the results.

Major Programs and Plans

1985	water treatment plant	$2,000,000
1986	modified the air filtration system	$2,000,000
1988	installation of the drum shredder	$500,000
1989	replaced battery classification system	$2,500,000
1990	new scrap battery receiving station	$500,000
1991	improved battery classification system	$500,000
1992	wood pallet shredder	$500,000
1994	installed after-burner &	$2,500,000
	completed secure slag monofill	$2,500,000
1995	replaced battery crusher with an improved version &	$500,000
	waste oils consumption program	$500,000
	ISO/CEI 25 (IS09000) laboratory	
1996	spent oil filter substitution program &	$500,000
	new "Gor-tex" filter bags for bag-house	
1997	second long rotary kiln	$14,000,000
	Total	$29,000,000

Issues

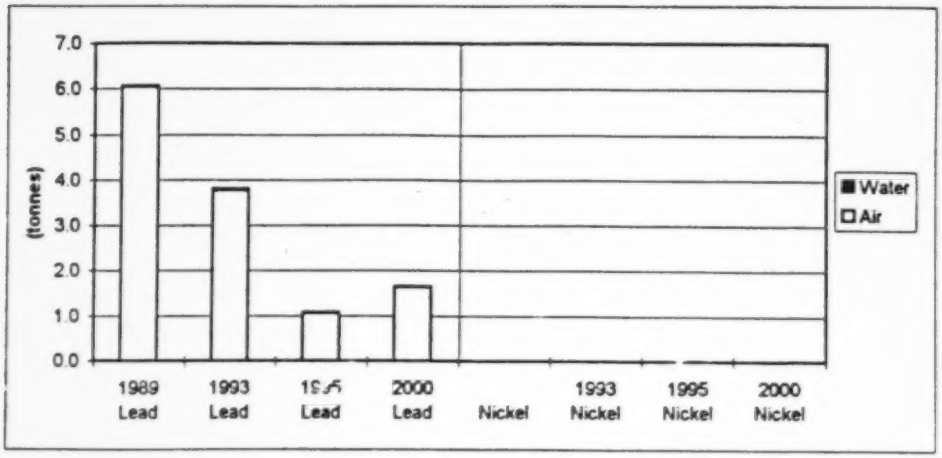
- Secure battery supplies.
- Reduce operational costs.
- Prioritization of health and environmental risk reduction opportunities
- Find an economical and environmental option to recycle the residual slag

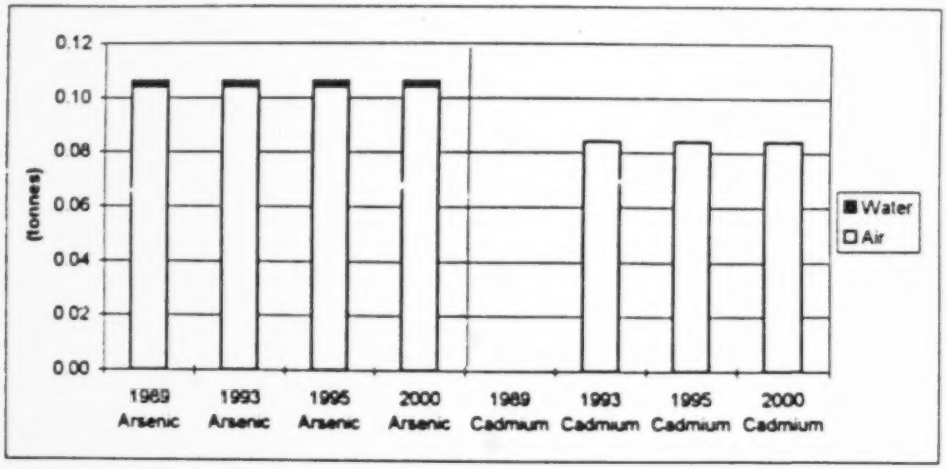
Table A6.13.2 **Releases to Air and Water and Off-site Transfers by Nova Pb Inc., Ville Ste-Marie, Quebec (tonnes) (Lead Smelter)**

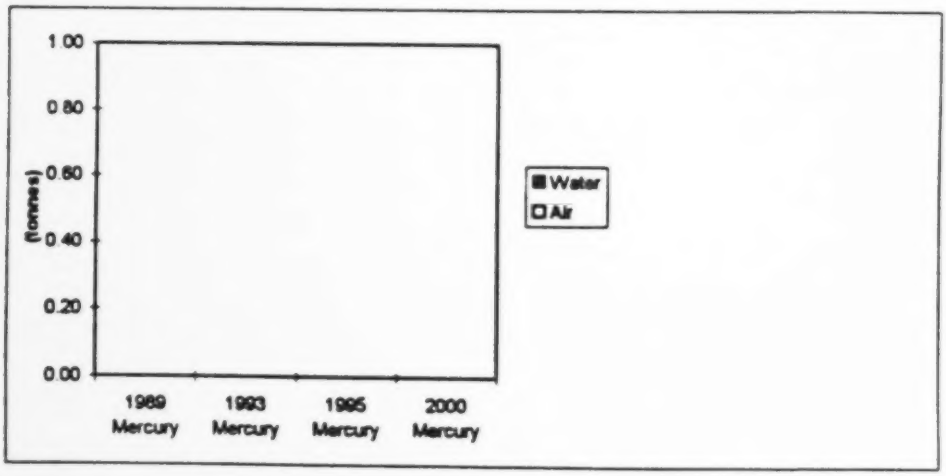
Year	1989	1993	1995	2000 P
Arsenic				
Air Releases	0.1	0.1	0.1	0.1
Water Releases	0.0	0.0	0.0	0.0
Total Releases	0.1	0.1	0.1	0.1
Transfers Off-site				
Cadmium				
Air Releases		0.1	0.1	0.1
Water Releases		0.0	0.0	0.0
Total Releases		0.1	0.1	0.1
Transfers Off-site		0.0	0.0	0.0
Lead				
Air Releases	6.0	3.8	1.1	<2
Water Releases	0.0	0.0	0.0	<0.016
Total Releases	6.1	3.8	1.1	<2
Transfers Off-site		0.0	0.0	0.0
Mercury				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				
Nickel				
Air Releases				
Water Releases				
Total Releases				
Transfers Off-site				

1988 Data is not available, but 1989 data has been provided.

Figure A6.13.2 Nova Pb Inc. Releases to Air and Water







Technical Options to Achieve Further Release Reductions

The increase smelting capacity will cause a increase demand in cooling waters at the refinery and post-combustion unit, hence as stated earlier the effluent releases will be nonexistent. Also the final installation of a "Gor-tex" filter bags will further decrease Nova Pb's emissions.

In summary, as a corporate policy, Nova Pb Inc. has taken the position that sound pollution and health controls are not only a cost of doing business, but in fact are a pre-requisite for doing business. As a producer and consumer of lead during the 1990's we believe that this position is not only vital for our long-term survival and growth, but it is also in the best interest of our suppliers and clients. In the future, as the case in the past, Nova Pb will continue to invest heavily in new state-of-the-art environmental controls and technology in an attempt to not only comply with, but exceed all environment compliance norms by a significant margin.

Although the lead-acid battery has enjoyed one of the most enviable recycling rates of any metal, currently in excess of 93%, due to the nature of the material all efforts must be encouraged to increase this recycling rate. Not only will this decrease the burden on the already over-taxed waste stream, but it will preserve the world's finite resources so that they can be enjoyed by future generations.

6.14 NORANDA MINING AND EXPLORATION INC. DIVISION MINES GASPÉ MURDOCHVILLE, QUÉBEC

Profile

Noranda Mining and Exploration Inc., Division Mines Gaspé operates a copper smelter at Murdochville, Québec. The plant commenced production in 1955 to process copper concentrates produced by the associated mine-mill complex. An acid plant entered service in 1974. The smelter now processes copper concentrate produced by the company's mines at Murdochville and near Bathurst and Miramichi, New Brunswick and custom concentrates from a variety of sources. The smelter produces copper anodes and sulphuric acid and emission control dusts containing lead, antimony, arsenic, cadmium and other impurities as well as copper. Selected production data for the period 1988 to 1995 are presented in Table A6.14.1, which includes projected levels for the year 2000.

Table A6.14.1 Production Summary (tonnes)

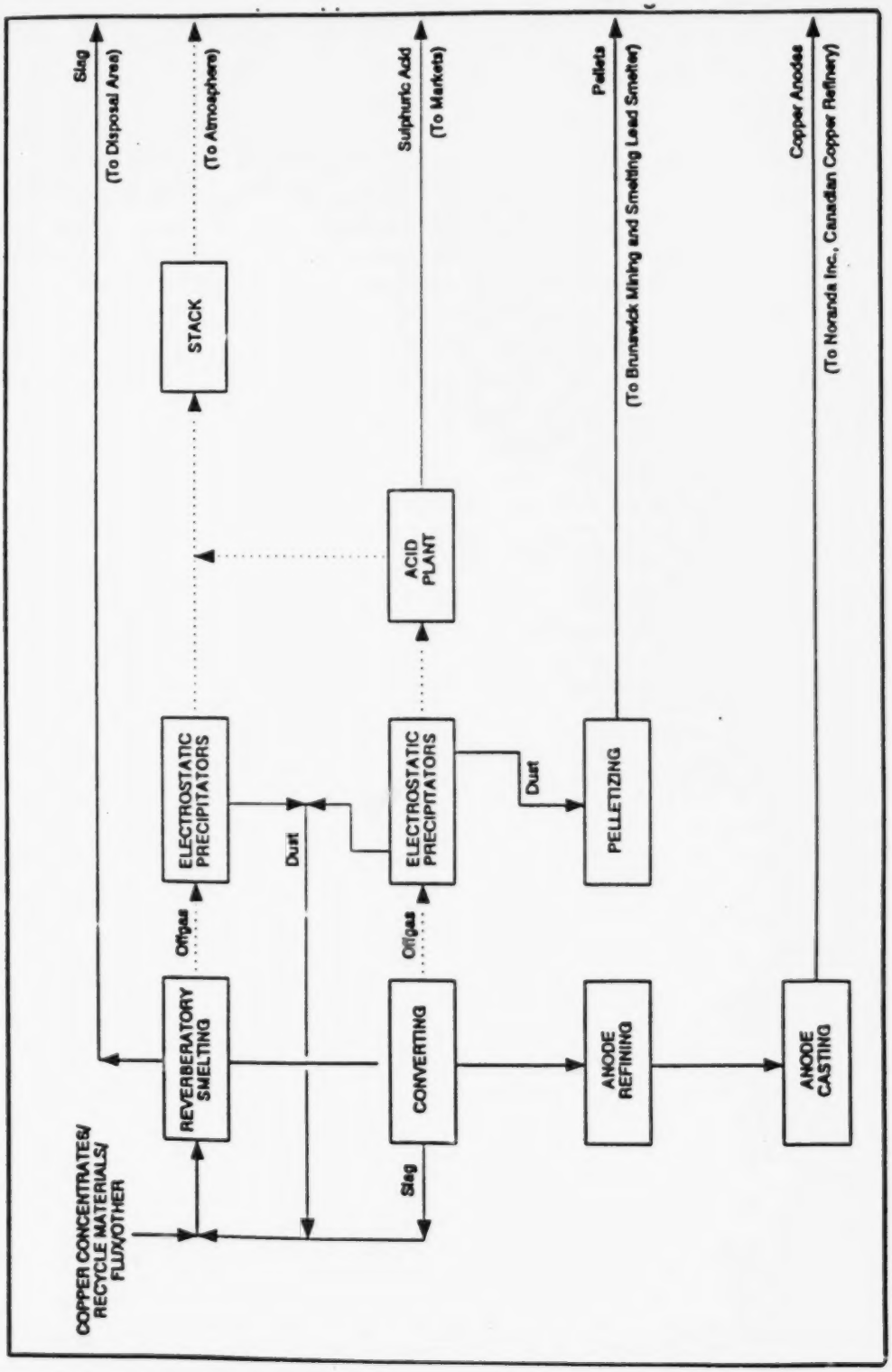
Products	1988	1993	1995	2000 (Projected)
Copper anodes	65,800	68,000	102,700	125,000
Sulphuric acid	132,100	152,900	164,600	261,000

Process Description

The process is outlined in Figure A6.14.1. Copper concentrate, limestone and silica are proportioned to form a low viscosity $CaO\text{-}SiO_2$ slag with low copper content. New feed is mixed with recycled slag and dust from the smelter and processed in a single reverberatory furnace. Most of the copper, iron and sulphur in the smelter feed is contained in sulphide minerals and reports to the molten sulphide matte phase, while the bulk of the non-sulphide gangue forms a barren oxide slag. The higher density matte separates from the slag, which is poured into slag pots and conveyed to a disposal area. Off-gases from the reverberatory furnace are treated by a dry electrostatic precipitator to remove particulate matter prior to release. All emission control dusts from the electrostatic precipitator are returned to the reverberatory furnace or to the converters via the injection system.

Matte is processed on a batch basis in two extended Pierce-Smith converters to oxidize sulphide sulphur to sulphur dioxide and reduce copper to the metallic state. Oxygen-enriched air is used to convert iron sulphide to iron oxide, which combines with added

Figure A6.14.1 Noranda Gaspé Copper Smelter Process Flow Sheet



flux to form an oxide slag and separates from the copper sulphide matte phase. This slag contains relatively high copper levels and is returned to the reverberatory furnace. As the converter cycle continues, copper sulphide is converted to blister copper containing dissolved sulphur and oxygen. Conversion of iron and copper sulphides produces converter off-gases containing substantial quantities of sulphur dioxide at concentrations which vary over the course of the batch operation. Converter off-gases are treated by a dry electrostatic precipitator to remove particulate matter. Dust is returned to the reverberatory furnace or to the converters via the injection system for recovery of copper and is also bled from the circuit to control impurity levels and reduce emissions of the more volatile metals. The dust bleed stream containing lead at >40% Pb in addition to cadmium, arsenic and other impurities is pelletized and shipped to Brunswick Smelting Division for recovery of lead. The clean converter off-gases are then directed to a single absorption sulphuric acid plant for recovery of sulphur dioxide. Weak acid solution from the acid plant is neutralized with lime to precipitate gypsum and metal hydroxides, combined with mill tailings and codeposited in the tailings impoundment area.

Blister copper is processed in an anode refining furnace to remove most of the dissolved oxygen and sulphur. The product is then cast into copper anodes which are shipped to Noranda Metallurgy Inc.'s CCR Division in Montréal-East for electrolytic refining.

Releases

Point sources of releases to air and water from the smelter are shown in Figure A6.14.1 and controlled as outlined above.

Dry process gases from the reverberatory furnace and converters are treated by dry electrostatic precipitators for particulate control. Process gases from the reverberatory furnace containing lower concentrations of sulphur dioxide are not strong enough or consistent enough in strength to be sent to an acid plant and are released to the atmosphere. Process gases from the converters containing higher and less variable concentrations of sulphur dioxide are treated by a single absorption acid plant. These controls maintain buildings under negative pressure and reduce fugitive emissions from process equipment.

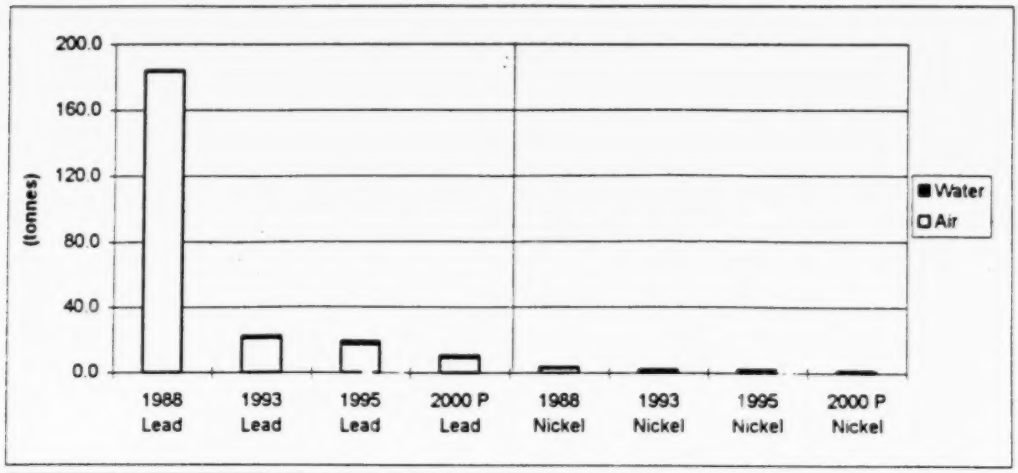
All liquid effluent from the acid plant site is collected, combined with mill tailings, treated and monitored. Smelter cooling waters are partly recycled.

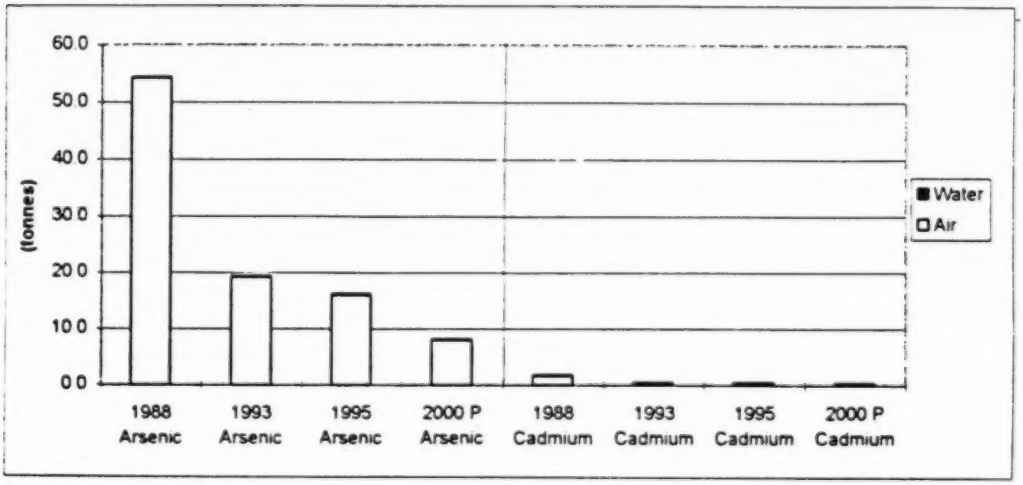
Selected release data for the period 1988 to 1995 are presented in Table A6.14.2 and Figure A6.14.2 and projected levels for the year 2000 are included. Releases of *CEPA* substances decreased by over 84% from 1988 to 1995 and further release reductions are projected.

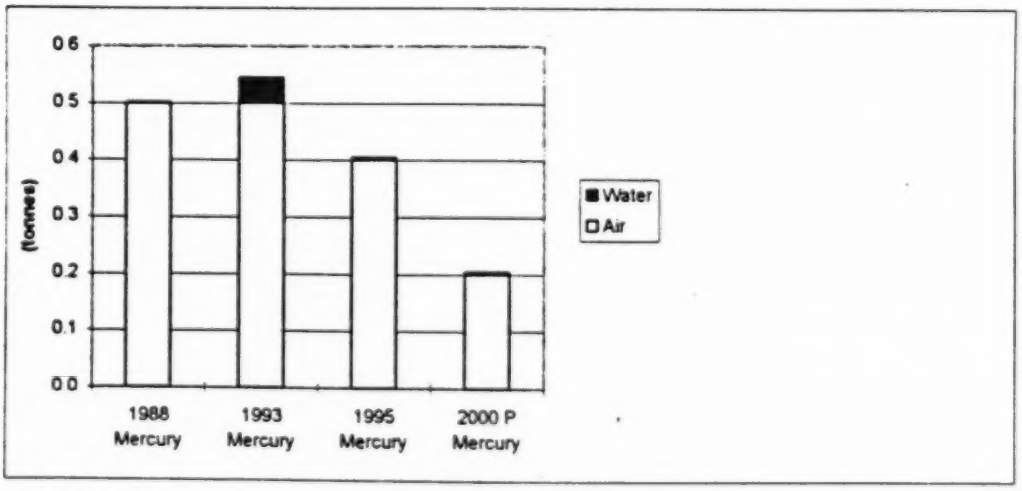
Table A6.14.2 **Releases to Air and Water and Off-site Transfers by Noranda Gaspé, Murdochville, Quebec (tonnes) (Cu Smelter)**

Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	54.2	19.2	16.0	8.0
Water Releases	0.2	0.2	0.3	0.2
Total Releases	54.4	19.4	16.3	8.2
Transfers Off-site		0.0	0.0	0.0
Cadmium				
Air Releases	1.6	0.3	0.2	0.2
Water Releases	0.3	0.2	0.3	0.2
Total Releases	1.9	0.5	0.5	0.4
Transfers Off-site		0.0	0.0	0.0
Lead				
Air Releases	183.2	20.9	17.0	9.0
Water Releases	0.8	1.4	2.0	1.4
Total Releases	184.0	22.3	19.0	10.4
Transfers Off-site		0.0	0.0	0.0
Mercury				
Air Releases	0.50	0.50	0.40	0.20
Water Releases	0.00	0.05	0.01	0.01
Total Releases	0.50	0.55	0.41	0.21
Transfers Off-site		0.00	0.00	0.00
Nickel				
Air Releases	2.8	0.9	0.7	0.4
Water Releases	0.6	1.2	1.3	1.1
Total Releases	3.4	2.1	2.0	1.5
Transfers Off-site		0.0	0.0	0.0

Figure A6.14.2 Noranda Gaspé Releases to Air and Water







Regulatory and Non-Regulatory Programs

The copper smelter and mine-mill complex are regulated by Québec. An SO_2 emission standard of 275 kg/tonne of dry concentrate smelted was implemented by regulation in 1985. Québec has also established a particulate emission standard of 50 mg/m^3. The air quality regulations are under review and are expected to be amended to limit SO_2 and particulate emissions from the Gaspé smelter as follows:

Compliance Date	SO_2 Emissions	Particulate Emissions
At promulgation	<30% of input sulphur	<3.0 kg/t (feed basis)
2002 01 01	<20% of input sulphur	<1.75 kg/t (feed basis)

Québec has also established ambient SO_2 air quality standards for hourly, daily and annual averaging periods. The current standard for the hourly mean concentration is 0.50 ppm. The regulation under review would reduce the standard to 0.34 ppm but would allow for exceedances of not more than 0.20% of the total sampling hours provided that the concentration does not exceed 0.50 ppm.

The smelter effluent is combined with that from an active mine that is an existing mine. The effluent is therefore subject to the *Guidelines for the Control of Liquid Effluents from Existing Metal Mines* under the *Fisheries Act* as well as to the general prohibition of deposits of deleterious substances in Subsection 36(3) of the *Fisheries Act*

Mining liquid effluent are also regulated by Québec under Directive 019. Mines Gaspé has a more stringent standard of 0.10 mg/L total copper in the final effluent due to its proximity to the York River, an important salmon river.

Noranda accepted the ARET challenge in 1994 and submitted an action plan that detailed specific goals for each substance. Noranda's goals were reviewed and updated in mid-1996 and reported to ARET

Monitoring and Research

The ambient air sampling network includes two continuous SO_2 monitors, linked to the Intermittent Control System, one suspended particulate sampler and twelve dustfall sampling sites located within 15 kilometers of the main stack.

The water sampling network is comprised of 20 stations both internal (for control purpose) and external (final effluent and control stations on tributaries of the York river. Biological studies at five to eight stations are conducted annually by consultants.

Programs and Plans

1988	Mining suspended due to a major underground fire in 1987.
	Modified intermittent control system to improve ability to predict and prevent exceedances of ambient air quality standards for SO_2 at a cost of $50,000.
	Revegetated tailings dams to reduce wind erosion at a cost of $1.5 million.
1989-1995	Completed soil replacement program in the town of Murdochville to reduce exposure to lead. Over 500 residential lots were stripped and resodded on the initiative of Mines Gaspé at a cost of $2.5 million.
1990-93	Refurbished acid plant mist precipitators at a cost of $2.0 million.
1991-93	Developed and installed system to compact electrostatic precipitator dust, reducing high dust recirculation, point source and fugitive emissions at a cost of $0.7 million.
1993	Improved furnace operating procedures resulted in reduced metal emissions.
1993-95	Further revegetation of tailings dams to reduce wind erosion at a cost of $0.75 million.
1994	Extended Pierce-Smith converters and installed conveyor system to feed compacted electrostatic precipitator dust and concentrate pellets to the converters at a cost of $2 million.
1995	Announced $28 million mine-smelter modernization and expansion project.
1996	Commissioned systems for concentrate drying and injection to the converters to increase production, reduce releases and increase sulphur fixation from approximately 68% to 77% at a cost of $10 million.
	Commenced detailed engineering at a cost of $0.75 million for installation of a third converter to increase production, reduce releases and increase sulphur fixation to approximately 82%.
1998	Anticipated commissioning of third converter at a cost of $18 million.
2000	Anticipated cessation of underground mining due to depleted ore reserves.

Issues

Sulphur dioxide emissions from the reverberatory furnace.

Fugitive emissions from the converters.

Technical Options to Achieve Further Release Reductions

An Environment Canada report for the Acidifying Emissions Task Group characterizes Gaspé as a medium size copper smelter with an acid plant. From a national perspective, SO_2 emissions are moderate at this site and further reductions would have little effect on the larger national picture. Plans to increase SO_2 recovery will be partially offset by production increases but will nevertheless contribute to improved local air quality.

Mines Gaspé is the only Canadian smelter to recover SO_2 emissions from Pierce-Smith converters. SO_2 is not recovered from the reverberatory furnace off-gases, but the facility employs state-of-the-art pollution control technology and management practices and has no significant uncontrolled sources of metal releases. Incremental release reductions may be achievable with continual improvement. Further reductions in releases and occupational exposures would be technically possible with a major investment in currently available state-of-the-art process technology. Such an investment (on the order of $0.5-1 billion) would improve workplace quality, reduce energy consumption and operating costs, provide the flexibility to produce liquid SO_2 instead of sulphuric acid and improve competitiveness but would eliminate a number of highly paid jobs. Security of feed supplies is a barrier to such an investment.

6.15 NORANDA MINING AND EXPLORATION INC. BRUNSWICK SMELTING DIVISION BELLEDUNE, NEW BRUNSWICK

Profile

Noranda Mining and Exploration Inc., Brunswick Smelting Division operates a primary lead smelter at Belledune, New Brunswick. The plant commenced production in 1967 and was originally built and operated to process bulk lead-zinc concentrates using the Imperial Smelting Process. An acid plant and fertilizer plant entered service in 1968. The smelter was converted to a lead smelter in 1972 and now processes lead concentrate produced by the company's mines near Bathurst and Miramichi, New Brunswick, custom concentrates and other lead-bearing materials from a variety of other sources. The smelter produces refined lead, lead alloys, silver doré, sulphuric acid and refinery coproducts containing copper, antimony, arsenic and other impurities. Selected production data for the period 1988 to 1995 are presented in Table A6.15.1, which includes projected levels for the year 2000. Smelter production increased by over 70% from 1988 to 1995.

Table A6.15.1 Production Summary (tonnes)

Products	1988	1993	1995	2000 (Projected)
Lead (Note 1)	61,700	76,100	105,000	125,000
Sulphuric acid (Note 2)	155,000	99,500	148,700	165,000

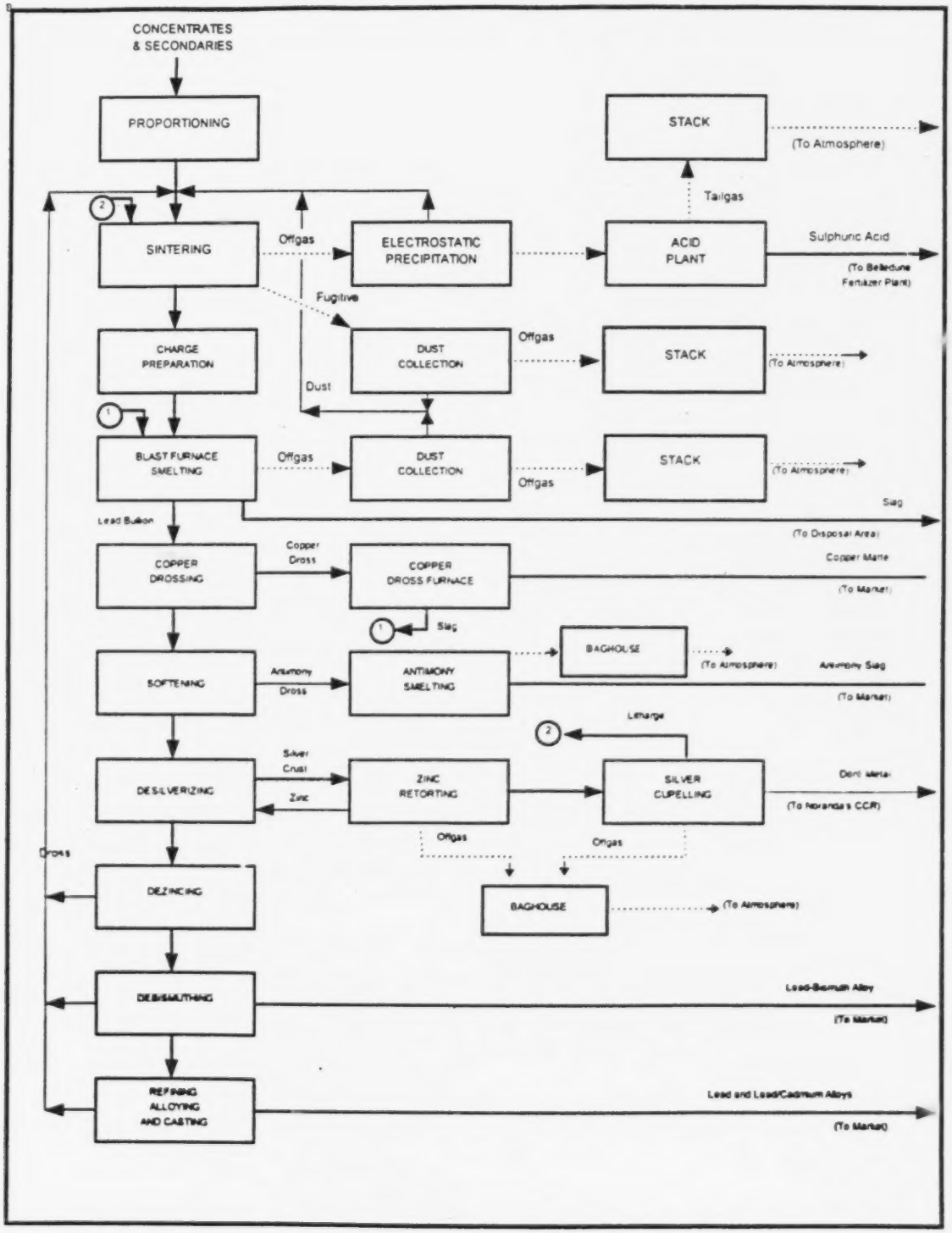
NOTES

1. Production data for lead includes refined lead, lead alloys and other lead products.
2. Prior to mid-1996, Brunswick Smelting Division converted smelter acid to diammonium phosphate fertilizer. These data include smelter production only and exclude acid receipts from other sources.

Process description

The process is outlined in Figure A6.15.1. Lead-bearing materials are received by road, rail or sea, both in bulk and in drums or other packages. Lead-bearing materials are unloaded and stored in buildings. A battery breaker and a new facility for concentrate handling and storage were commissioned in 1996. Battery plates and pastes are processed, plastics are sold for recycling and acidic wash water is collected and used for pH control at the waste water treatment plant.

Figure A6.15.1 Noranda Brunswick Process Flow Sheet



Lead concentrate, limestone and silica are proportioned to form a low viscosity, low melting point $FeO-CaO-SiO_2$ slag with low lead content and suitable refining properties. New feed is mixed with recycled materials from the smelter and processed in a sinter machine to oxidize sulphide sulphur to sulphur dioxide. Moisture is added to sinter plant return fines and fresh feed to produce a porous and reactive basic lead-iron silicate sinter with suitable mechanical properties. All sinter plant off-gases are cleaned to remove particulate matter prior to further processing or release. Strong gases are treated by a venturi scrubber and wet electrostatic precipitator, cooled and directed to a single absorption sulphuric acid plant. Weak gases are treated by the sinter baghouse prior to discharge. Moist gases from the sinter machine and sinter recycle cooling containing submicron fines are treated by wet scrubbers. All emission control dusts from the sinter plant and gas cleaning are returned to the sinter machine as a dust or slurry, except if electrostatic precipitator dust is required to be bled from the circuit to control impurity levels.

Sinter at <2% S is processed in a blast furnace using metallurgical coke both as a fuel and as a reductant to reduce lead to the metallic state. Blast air is enriched with oxygen to reduce energy consumption and all off-gases from the blast furnace are cleaned by a baghouse to remove particulate matter prior to release. Furnace baghouse dust is returned to the sinter machine as a slurry, except as required to be bled from the circuit to control impurity levels. Lead bullion and slag are continuously tapped from the furnace and separated. Slag is granulated by quenching with water to preserve the environmentally stable high temperature, vitreous structure and is dewatered and trucked to an engineered impoundment area.

Lead bullion is processed in batches by a thermal refinery to produce refined lead at >99.9% Pb. Pumps in some sections have replaced bailing or pouring of lead bullion to minimize safety risks and reoxidation of lead. The lead refinery is ventilated to minimize worker exposure and all off-gases are treated by a baghouse prior to release. Copper dross is first removed and processed in a reverberatory furnace to recover entrained lead and other values by separating four distinct phases: an oxide slag containing iron and zinc, intermetallic speiss containing copper arsenide, antimonide and stannide and enriched in silver and gold, copper-lead sulphide matte enriched in silver and metallic lead bullion enriched in silver and gold. Matte and speiss are sold for processing by a copper smelter. Bullion is further refined by removing residual copper with sulphur, softening the lead by oxidizing residual antimony, tin and arsenic with caustic soda, removing silver by precipitation with zinc, removing zinc with caustic soda, removing bismuth with magnesium and calcium and finally removing any residual impurities with caustic soda. Zinc-silver crust is oxidized to produce Doré metal, an impure silver bullion containing >96% Ag which is shipped for further refining. Other refinery byproducts may be further processed or sold. Refined lead may be alloyed with calcium, tin or antimony prior to casting into a variety of shapes for shipment to customers.

Two short rotary furnaces are used primarily for melting of scrap battery plates but may also be used to further process a wide variety of smelter or refinery byproducts. Off-gases from the short rotary furnaces are treated by a baghouse prior to release.

A recycled process water system collects process water from the sinter and acid plants for reuse in order to minimize raw water use and metal discharges to the environment. Under normal operating conditions there is no discharge. Any surplus process water is directed to the cooling recycle pond, which receives slag granulation water as well as surface water. Water from the cooling recycle pond is used for slag granulation and cooling of the furnace top. A waste water treatment plant treats all excess water prior to discharge for removal of arsenic, cadmium, lead, copper, zinc and other metals by lime neutralization and air oxidation of iron and arsenic to precipitate metal hydroxides and gypsum. Water treatment sludge is reprocessed by the smelter.

Releases

All point sources of releases to air and water from the smelter and refinery are shown in Figure A6.15.1 controlled as outlined above.

Dry process gases from the sinter plant, blast furnace and refinery are treated by baghouses. Process gases from the sinter plant containing high concentrations of sulphur dioxide are treated by a venturi scrubber, wet electrostatic precipitator and single absorption sulphuric acid plant. Wet process gases from the sinter plant are treated using wet scrubbers. These controls maintain buildings under negative pressure and minimize fugitive emissions from process equipment. Fugitive emissions from materials handling and storage are minimized by engineering controls and best management practices. All lead-bearing materials are unloaded and stored in enclosed buildings. Newer buildings are maintained under negative pressure by baghouses, while equipment and procedures in the older raw materials storage building have been modified to reduce fugitive emissions and worker exposure. Conveyors are fully enclosed and materials are transported as a slurry or sludge where appropriate. The site is paved and mobile equipment is used to keep roadways free of dust and to minimize windborne transport.

All liquid effluent from the smelter site is collected, treated and monitored. Liquid effluent from the engineered slag impoundment area has been monitored since 1980. Leachate and runoff from the slag impoundment area could be directed to the effluent treatment system if the water was to contain metal levels above specified limits.

Selected release data for the period 1988 to 1995 are presented in Table A6.15.2 and Figure A6.15.2 and projected levels for the year 2000 are included. Releases of *CEPA* substances decreased by over 73% from 1988 to 1995 and further release reductions are projected.

Regulatory and non-regulatory programs

The lead smelter and refinery are subject to the *Secondary Lead Smelter Release Regulations* under the *Canadian Environmental Protection Act*, which establish legally enforceable limits for particulate emissions containing lead. The regulations require monitoring and reporting. The monitoring data demonstrates that the facility complies with the release limits in the federal regulations.

The lead smelter and refinery are also regulated by New Brunswick. The *Air Quality Regulation* under the *Clean Environment Act* establishes legally enforceable limits for the average hourly, daily and monthly concentration of sulphur dioxide in ambient air. Separate Certificates of Approval to Operate issued under the *Air Quality Regulation* and the *Water Quality Regulation* under the *Clean Environment Act* prescribe site specific point source and other standards.

All standards are legally enforceable limits and include particulate concentration limits for all major point sources of air emissions and liquid effluent concentration limits for arsenic, cadmium and lead as well as other metals and a lower limit for pH. The air approval requires the smelter to develop and implement a proactive program to respond to ambient air quality results in excess of 17 pphm SO_2, a level corresponding to 50% of the 34 pphm SO_2 hourly average ambient air quality limit prescribed by the *Air Quality Regulation*.

Brunswick Smelting Division participated in a multistakeholder committee established for the Nepisiguit Air Resource Management Area in accordance with New Brunswick's December 1993 Clean Air Strategy. The committee submitted a consensus report to the Minister of the Environment in late 1996.

The predecessor company, Brunswick Mining and Smelting Corporation Limited, was recognized by the federal Minister of Natural Resources in 1995 as an Energy Innovator and committed to further energy efficiency improvements through the Voluntary Challenge Registry.

The predecessor company accepted the ARET challenge in 1994 and submitted an action plan that detailed specific goals for each division. Goals were reviewed and updated in mid-1996 and incorporated into Noranda's action plan.

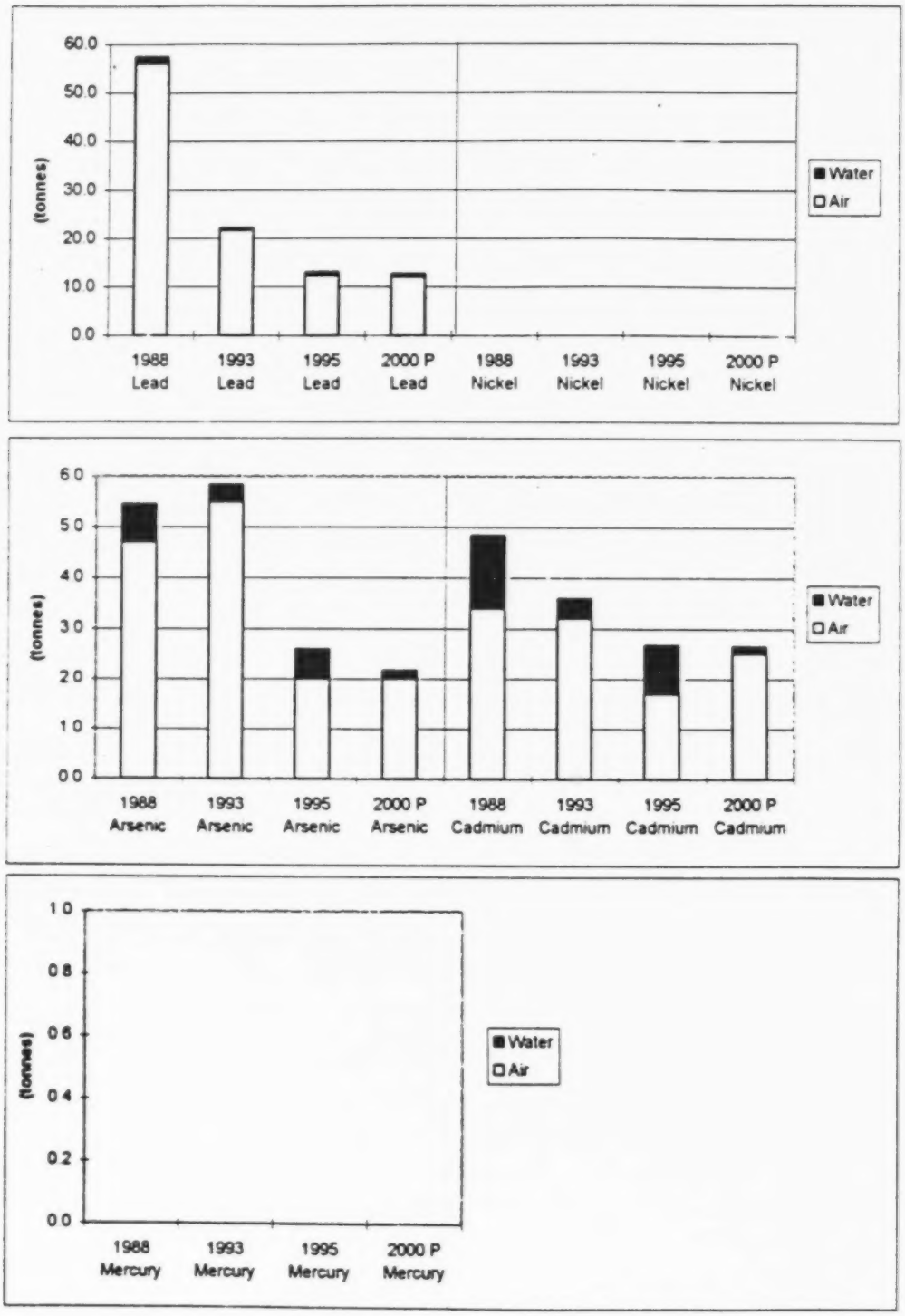
Monitoring and research

SO_2 concentrations are continuously monitored for emissions from the sinter baghouse and acid plant stacks and opacity is continuously monitored for emissions from the sinter baghouse and furnace baghouse stacks. The smelter also operates a 10 metre meteorological monitoring station. Periodic isokinetic stack sampling is conducted to determine particulate concentrations and particulate and metal emission rates for all baghouses and wet scrubbers.

Table A6.15.2 **Releases to Air and Water and Off-site Transfers by Noranda Brunswick, Belledune, New Brunswick (tonnes) (Lead Smelter)**

Year	1988	1993	1995	2000 P
Arsenic				
Air Releases	4.7	5.5	2.0	2.0
Water Releases	0.8	0.3	0.6	0.2
Total Releases	5.5	5.8	2.6	2.2
Transfers Off-site		0.0	0.0	12.0
Cadmium				
Air Releases	3.4	3.2	1.7	2.5
Water Releases	1.5	0.4	1.0	0.2
Total Releases	4.9	3.6	2.7	2.7
Transfers Off-site		0.0	0.0	30.0
Lead				
Air Releases	56.0	21.7	12.2	12.0
Water Releases	1.3	0.4	0.7	0.6
Total Releases	57.3	22.1	12.9	12.6
Transfers Off-site		0.0	0.0	300.0
Mercury				
Air Releases	0.00	0.00	0.00	0.00
Water Releases	0.00	0.00	0.00	0.00
Total Releases	0.00	0.00	0.00	0.00
Transfers Off-site		0.00	0.00	0.75
Nickel				
Air Releases	0.0		0.0	0.0
Water Releases			0.0	0.0
Total Releases	0.0		0.0	0.0
Transfers Off-site			0.0	

Figure A6.15.2 Noranda Brunswick Releases to Air and Water



Effluent treatment plant flow and effluent pH are continuously monitored and controlled. Daily composite effluent samples are collected and analysed for arsenic, cadmium and lead as well as other metals. Metal discharges are calculated on the basis of daily concentration and flow and are corrected for periods that effluent is recycled and not discharged.

Concentrations of SO_2 in ambient air are continuously monitored at four company monitoring stations. During 1996 a system was implemented to share monitoring data with an adjacent thermal generating station. The company operates high volume air samplers at five locations on a six day cycle to determine total suspended particulate, arsenic, cadmium and lead concentrations over a 24 hour sampling period. Results are compared with New Brunswick's ambient air quality standards for total suspended particulate and with guidelines for metal concentrations established by other jurisdictions.

Other routine chemical monitoring includes characterization of metal concentrations in soils, groundwater, forage crops, garden produce, mussels, marine sediments and lobster. The smelter also monitors workplace contaminant levels and worker exposures to arsenic, cadmium, lead and other contaminants.

Monitoring of effects on benthos and other biota have focused on the marine environment, with most relating to the fertilizer plant rather than the smelter, but health and environmental risks associated with exposure of lobsters to cadmium and other metals has also been examined. A comparative study of lobster growth rates at Belledune and in an unexposed population at a control location concluded that there was no significant difference in growth rates.

Concerns about workplace hazards led to three studies of occupationally exposed workers at Belledune. The most recent study was commissioned by the company, in cooperation with the United Steelworkers of America and the New Brunswick Occupational Health and Safety Commission (now the New Brunswick Workplace Health, Safety and Compensation Commission) and was completed in 1993. That study concluded in part that 25 employees or former employees performed below expectations on psychological and neurological tests which could have been partially due to exposure to lead, but that the smelter was currently a healthy workplace with comprehensive Industrial Hygiene and Occupational Health programs in place, and there was no reason why all of those employees could not return to their normal employment.

Health and environmental surveys have been completed by several government departments. Data have been made available upon request but in most cases an interpretation of the results has not been published. Data relevant to the smelter were recently summarized in a report published by the New Brunswick Department of the Environment. Data on public health studies is sparse, but the limited data reported for

a 1985 study of lead concentrations in deciduous teeth collected by the New Brunswick Department of Health and Community Services from children living in the vicinity of the smelter and two other areas in the province indicated that lead content was lower near the smelter. The regional Air Resource Management Area Committee report includes a recommendation that departments should publish such data together with an interpretation, to ensure that industry and the public have access to all available information and to avoid public perceptions that unpublished data may indicate an unaddressed problem when it may be that the data do not indicate any cause for concern. The Committee also recommended that the province should expand its own ambient air quality monitoring network to include a station in the Bathurst area.

Programs and plans

1988 Installed ground water monitoring network.

Commissioned short rotary furnaces for processing recyclable materials. Stockpiled furnace baghouse dust to control cadmium losses in recycled process water.

1989 Publicly committed to reduce SO_2 emissions by 25% from 1988 levels. Replaced recycled process water pipeline with an above ground line.

1990 Commissioned expanded silver refinery baghouse at a cost of $1.5 million.

Initiated processing of higher grade lead concentrate.

Modified changehouse to reduce worker and family exposure through improved hygiene.

Implemented no smoking policy to reduce worker exposure to cadmium and lead.

1991 Replaced wet electrostatic precipitator at a cost of $5 million.

1994 Upgraded effluent treatment plant instrumentation and process control at a cost of $0.5 million.

Conducted environmental awareness training for all employees.

Completed refresher training for all effluent treatment plant operators.

1995 Lined once-through salt cooling water discharge pipeline to prevent ingress of contaminated groundwater and collected contaminated groundwater for treatment at a cost of $0.5 million.

1996 Replaced acid plant startup heat exchanger at a cost of $0.5 million.

Commissioned battery breaker at a cost of $1 million.

Consolidated concentrate handling facilities at a cost of $17 million.

1997 Replace acid plant contact section, including introduction of an improved converter catalyst to achieve lower tail gas SO_2 concentrations, at a cost of $8 million.

Improve continuous monitoring of particulate emissions.

Develop and implement formal environmental management system.

Issues

Security of lead concentrate supply with declining domestic production.

Need for continued improvements to maintain or improve competitive position and generate cash to fund new investment.

Prioritization of health and environmental risk reduction opportunities.

Technical options to achieve further release reductions

An Environment Canada report for the Acidifying Emissions Task Group notes that, from a national perspective, SO_2 emissions are low at this site and further reductions would have little effect on the larger national picture. Planned improvements underway will result in SO_2 reductions that will contribute to improved local air quality.

The facility employs current state-of-the-art pollution control technology and management practices and has no significant uncontrolled sources of metal releases. Incremental release reductions may be achievable with continual improvement. Further reductions in releases and occupational exposures would be technically possible with a major investment in currently available state-of-the-art process technology. Such an investment (on the order of $0.5-1 billion) would improve workplace quality, reduce energy consumption and operating costs, provide the flexibility to produce liquid SO_2 instead of sulphuric acid and improve competitiveness but would eliminate a number of highly paid jobs. Security of feed supplies is a barrier to such an investment.

APPENDIX 7

Views of the Toxics Caucus of the Canadian Environmental Network on the Impact of Mining and Smelting on the Environment

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APPENDIX 7 - Views of the Toxics Caucus of the Canadian Environmental Network on the Impact of Mining and Smelting on the Environment

The mining industry causes several major, negative effects on Canada's environment and many of these are large scale, permanent and often irremediable. The enormity of the sector's impact on the environment can be summarized as follows[10]:

- excavation and ore removal involves destruction of habitat, increased erosion, land subsidence, and contamination of lakes, streams and groundwater. In fact, as of 1982 over 279,000 hectares of land have been disturbed, utilized and alienated by mining in Canada.
- ore concentration may include waste generation, acid drainage, and contamination of lakes, streams and groundwater.
- the smelting and refining process releases large quantities air pollution including metals, carbon dioxide and sulphur dioxide, produces slag as waste, and consumes considerable electrical power (resulting in a range of environmental effects). In 1994, for instance, the primary metal sector in Manitoba, Ontario and Quebec released over 1.8 billion pounds of SO2.
- the Government of Canada has estimated that the Canadian mineral industry generates 1 million tonnes of waste rock and 950,000 tonnes of tailings *per day*, resulting in some 650 million tonnes of waste per year. This is more than twenty times the amount of municipal waste generated each year by all of the residences, industries, commercial establishments and institutions in Canada combined.
- mining operations are also significant sources of water pollution, in particular through acid mine drainage (AMD), estimated at some 511 million tonnes of sulphide tailings. In addition, some 54% of all effluents from Ontario mining and refining facilities were found to be acutely toxic to rainbow trout.
- the estimated 10,000 abandoned mines and 6,000 tailings also have major environmental effects. In 1994, the Mining Association of Canada estimated the total cost of remediating abandoned mine sites in Canada at $6 billion.
- finally, environmental accidents continue to pollute the environment and cause human health damage. For example, between August 1987 and November 1995 at least 5 accidental releases of various gases at one company sent dozens of people to hospital.

[10]Data is referenced in a position paper by the CEN Toxics Caucus.